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Editor

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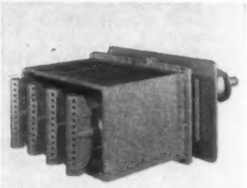

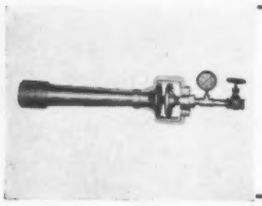

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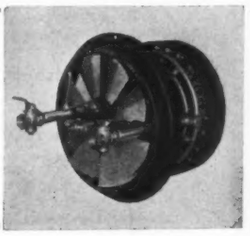

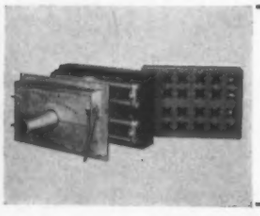

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THE LOOK BOX

STATUS of the role of refining in the synthetic-rubber program is still more of what can be done than what is being done. Its technologists have within a few months learned so much about the making of butadiene that there is confusion even within the industry. It would seem like good policy if all this knowledge could be put in condensed form and given to the public, as well as government and the industry itself.

Only Plants Can Make It

Above all, it should be stressed that it is plant capacity rather than processes that retards the actual making of rubber products. Regardless of what the technologists learn, construction is involved. It is gratifying that existing equipment can be used to a wider extent than the original construction anticipated. Even this does not bring the supply of rubber to a date early enough for comfort.

Butadiene can be made by dehydrogenating butane to butylene, which can be dehydrogenated to butadiene. It can be made by so operating catalytic cracking that the butadiene yield is high. A catalytic process can be added to thermal cracking. Vapor-phase processes can be linked with thermal units. Each approach will yield other desirable petroleum cuts along with the butadiene yield. As an expensive stopgap, higher temperatures applied to thermal cracking will produce butadiene.

How all of these can be worked into a harmonious program is a challenge to the industry. When several routes lead to one destination, the tendency is to devote time to selecting the best route. Perhaps the industry should proceed along all routes in its butadiene program, and it is this program which the public, government and the industry could profitably have.

The stake of this industry in rubber is too critical to allow for bickering. It amounts first to an essential for winning the war. As such it is of concern to the industry as it is to the welfare of the nation. But making a division between rubber for military use and that for other use calls for fine distinction. The munitions-plant worker needs be at his post and it looks like the economy of this country is too interwoven with automotive transportation to deny him tires.

Beyond this the petroleum industry has an interest in synthetic rubber to match its existence. Unless automobiles are maintained the industry will operate at financial loss. This may be a selfish viewpoint, still it exists. Consequently the industry could justify a plant expansion and conversion program that will provide rubber sufficient for domestic tire use.

What the industry has learned affords a premise for proposing that much. Early estimates were that each ton of plant capacity for Buna S rubber would cost $1,000. Now the estimate is $600 for each ton. That plant cost will be even lower seems reasonable.

Meanwhile what the technologists are learning

should not halt plant building. No production problem is completed in the laboratory. It is progress when a plant is antiquated before it is in operation. This may be offered as progress rather than accepted as cause for hesitation.

Done And Dismissed

IT WAS only a year ago that aviation gasoline was a stupendous, well nigh an impossible task. Many did not believe the goal set for the refining industry could be met on schedule. Now it has been several months since the matter has come to attention.

Meanwhile there has been nothing to indicate that any military airplane of the United Nations has been grounded for lack of fuel. Since it is not permissible to quote production figures, none have been sought. The conclusion is that the refining industry has provided what the war effort needs.

In part credit for that is due to the fact that both technologists and operating personnel learned a lot as they went along. Instead of waiting for new plants to be built, use was made of existing equipment, which was forced to yield choice ingredients under changed operating conditions.

Likewise aviation-grade lubricants are coming from equipment built for automotive oils. Specifications are more rigid and operating technique more exact, still the equipment installed for another product continues to produce what the military machine needs.

Perhaps there was over-optimism in those early claims that petroleum was ready for any emergency. It simply got ready as it went along.

Simple and Workable

PERHAPS it is too late and too simple to bring a shift in the attitude toward ordinary business, still the fact persists that a free economy is subject to less explosion than one determined by edict. Somehow the man or men who have not been found and will not be found with ability to comprehend the ramifications of ordinary business. They make an adjustment whose purpose is to prevent high prices. What they can not foresee is some other change, which converts the adjustment into an injustice.

Prices of oil are an example. OPA was given authority to determine prices, the object being to prevent inflation. Then came the shift from tankers to tank cars for hauling oil to the Atlantic Seaboard. Costs went up and the prices, which may have been just, became unfair.

Those with authority to fix prices have no authority to make appropriations. They may go to Congress and beg for relief. Congress which exists by pleading for votes is responsive to fixed prices, especially low ones, but is hard of hearing when the adjustment means a grant from the treasury. The one is for the people and the other is for the interests.

A free economy, which would allow prices to follow costs, would avoid such incidents, all of which must be old fashioned, however desirable it may be.

After Hours

THERE is hesitation as to suggesting that more statistics be added to the volumes that come from the ramifications of industry. Still it would be enlightening if something were known about the good effects of safety training, beyond the confines of the plant where men are trained in its methods.

The suggestion came out of this part of an announcement from The Atlantic Refining Company:

"Davenport, passing by, was attracted by the crowd and rushed in. He began at once the Shaeffer prone pressure method of artificial respiration which he had learned in first-aid classes at the refinery. He continued the rescue attempt unaided for a full hour until Mrs. Hennessy began to breathe again."

The news notice concerned presentation of a medal to Frank Davenport, a shift fire marshal. A daughter had found Mrs. Julia Hennessy overcome by gas. A crowd had collected. One man knew what to do and kept at it.

Keep This In Mind

EXCEPT Butyl rubber, the petroleum industry will not make either of the substitutes for rubber. This product is wholly from petroleum gases.

The Buna products are 75 percent butadiene, and part of this will come from grain. Petroleum refining will make most of the butadiene and some of the styrene for the Buna S product, best of the tire materials. The two products will go from refining plants to adjacent polymerization plants, which will be operated by the rubber industry. Here the product will be from liquid to crumbs to sheets, which will be worked into useful articles after methods used in natural rubber.

Neither is the petroleum industry, for its part of the rubber program, building anything radically different from what it has long used. A butadiene unit is similar to the furnaces and towers for gasoline production. Its materials are similar, the design is similar, temperatures and pressures are those long used in refining. Making butadiene is petroleum refining to one purpose.

Hydrocarbon Structure of Petroleum Is Complex

A. W. TRUSTY, Chief Chemist
Arkansas Fuel Oil Company

CRUDE petroleum consists mainly of a mixture of hydrocarbons of many chemical types and of varying degrees of molecular complexity. Petroleums from different localities, and even from dissimilar oil sands in the same field, often exhibit great variations in appearance, chemical composition and properties.

In some industries comprehensive research of a scientific character preceded the commercial development of the field. For example, the chemistry of coal tars was fairly well known and the various hydrocarbons of which coal tar was composed had been isolated and catalogued before commercial production. In the petroleum industry, despite the great number of chemists, physicists and engineers engaged in the study and handling of these products, very little is known thus far of its actual chemical make-up. Since the world production of petroleum is approaching a quarter of a billion tons annually, the question is often raised, "Why do we not know more of the chemical structure of petroleum?"

Two reasons for our lack of knowledge are offered: First, unlike most of the hydrocarbons occurring in coal tar, the petroleum hydrocarbons are comparatively non-reactive to the ordinary chemical reagents. Second, the recognition of the possible existence of literally thousands of hydrocarbons in a single commercial fraction has discouraged many chemists in attempting such a complex problem.

The hydrocarbon analysis of a petroleum product heavier than natural gasoline is very complicated. Difficulty in analysis by fractional distillation and other methods are due to:

1. Difference in boiling points of hydrocarbons diminishes with increasing molecular weights.
2. The number of isomers increases rapidly with increasing molecular weights.
3. Constant boiling mixtures.
4. Polymerization and depolymerization occurring before the boiling point is reached.

The large difference in the boiling points of the light hydrocarbons permits an easy separation of these gases. However, as shown by these examples, there is less differences in boiling points for adjacent members of a group when the molecular weight has increased:

FORMULA	Molecular Weight	Boiling Point F.
Pentane C_5H_{12}	72.1	97
Hexane C_6H_{14}	86.1	156
Eicosane $C_{20}H_{22}$	282	401
Heneicosane $C_{21}H_{44}$	296	419

Isomers

An isomer may be defined as a compound having the same elementary composition and the same molecular weight as another compound yet differing in chemical and physical properties. Starting with the first member of the paraffin series, methane, represented by the formula there can be but one compound with this formula. However, as the num-

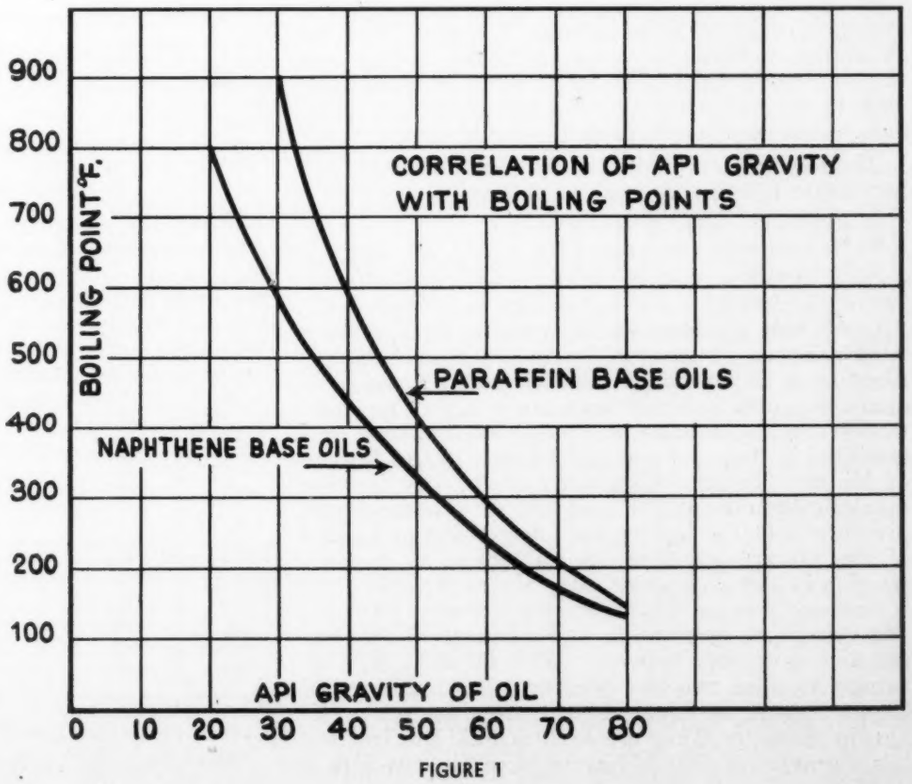

FIGURE 1

ber of carbon and hydrogen atoms increase, the possibility of arrangements of these atoms increases enormously. For example:

Number of Carbon Atoms in the Molecule	Number of Isomers or Possible Arrangements of Carbon and Hydrogen Atoms
3	1
4	2
5	3
7	9
10	75
15	4,347
20	366,319
25	36,797,588
40	62,491,178,805,831

The nearness of the boiling points of the isomers of one hydrocarbon makes the separation by distillation very difficult. For example, the isomers of octane:

	Boiling Point F.	Density (68 F.)
N-octane	258.1	.7028
2-Methylheptane	243	.6978
3-Methylheptane	246.2	.7057
d-3-Methylheptane	242.6	.710
1-3-Methylheptane	239	....
4-Methylheptane	244.4	.7163
3-Ethylhexene	245.5	.7128
2, 2-Dimethylhexane	224.6	.6956
2, 3-Dimethylhexane	240.3	.7124
1-2-3-Dimethylhexane	236.3	....
2, 4-Dimethylhexane	228.2	.6993
d-2-4-Dimethylhexane	232.3	.696
1-2-4-Dimethylhexane	230.9	.703
2-5-Dimethylhexane	228.7	.6949
3, 3-Dimethylhexane	231.8	.7086
3, 4-Dimethylhexane	244.2	.7195
2-Methyl-3-ethylpentane	237.2	.7182
3-Methyl-3-ethylpentane	245.1	.7256
2, 2, 3-Trimethylpentane	230.5	.7162
2, 2, 4-Trimethylpentane	210.7	.6919
2, 3, 3-Trimethylpentane	237.6	.7253
2, 3, 4-Trimethylpentane	236.1	.7195
2, 2, 3, 3-Tetramethylbutane	223.7	....

Although the refiner's knowledge of the exact chemical composition of his products is vague, research workers have developed means of analyzing light distillates to determine the quantity of the various groups of hydrocarbons. Knowing thus the proximate analysis of a product, the refiner and engineer have been able to correlate this analysis with the actual performance of the product in whatever commercial application it may be used.

The four general groups of hydrocarbons of which petroleum is composed are as follows:

1. Paraffins
2. Unsaturates
3. Aromatics
4. Naphthenes

Crude oils are classified as paraffin base when a predominance of paraffin hydrocarbons are found; likewise as a naphthene base oil when a predominance of such hydrocarbons are found. The commonly accepted method of classifying the base of a crude oil is that of Lane and Barton, of the Bureau of Mines[1]: "If the API gravity of the key fraction distilling between 482° F. and 527° F. at atmospheric pressure is 40.0 or lighter, the lower-boiling fractions of the oil are paraffinic in character; if the key fraction is 33.0 or heavier, they are naphthenic; and if the key fraction has a gravity between 33.0 and 40.0, they are intermediate. Similarly, if the key fraction distilling between 527° F. and 572° F. (under 40 m.m. absolute pressure) has a gravity of 30.0 or lighter, the higher-boiling fractions are paraffinic in character. They are naphthenic if this fraction has a gravity of 20.0 or heavier, and intermediate if the gravity is between 20.0 and 30.0." There are thus nine possible classes of crude oils.

The basis for this method of classifying oils is seen by comparing the boiling ranges and gravities of the paraffins and the naphthenes in Figure 1. For example, a paraffin fraction boiling at 800° F. has a gravity of 33.0; a naphthene fraction boiling at the same temperature has a gravity of about 20.0. No crude oils have been found that are made up of pure paraffin or naphthene hydrocarbons. The key fraction boiling between 482° F. and 527° F. of a pure paraffin oil would have an API gravity of over 50.0. Likewise, this same fraction if purely naphthenic would have an API gravity of between 25 and 30.

The paraffin and naphthenic hydrocarbons probably make up the greater part of crude petroleum. Light paraffin hydrocarbons are easily isolated, and most natural gases or other gases occurring with petroleum are composed mainly of paraffins. Solid paraffin wax, which is removed from crude petroleum or distillates by chilling and filtering, is composed almost wholly of paraffin hydrocarbons.

The existence of unsaturated hydrocarbons in crude petroleum, prior to distillation, is a question which has aroused considerable controversy. Most of the published analytical figures for gasoline and kerosine fractions of various crudes show the presence of small amounts of unsaturates. Since most of this work has been done on distillates, and since there is a possibility that these compounds may have been formed by pyrolysis, it is certain that if present at all, the proportions of unsaturated hydrocarbons are small.

The aromatic group of hydrocarbons have been isolated and definitely identified as occurring in crude petroleum. The proportion is small in most crudes, but considerable quantities have been found in Borneo crude.

Sachanen[2] shows an approximate composition of some typical crude oils:

Type of Crude Oil	Paraffins	Naphthenes	Aromatics
Paraffinic	46–61	22–32	12–25
Paraffinic, naphthenic	42–45	38–39	16–20
Naphthenic	15–26	61–76	8–13
Naphthenic, aromatic	0–8	57–78	20–35

Hydrocarbons in Gas

With the development of the low-temperature fractional distillation apparatus, the complete analysis of a natural gas can now be made accurately. For the most part these gases are composed of the lower paraffin hydrocarbons. Gases such as olefin or acetylene have never been found in natural gases. Small proportions of naphthenic and aromatic hydrocarbons have been reported. Some analyses of some typical gases are shown:

	Rodessa, La., Gas	Gas from East Texas Oil Wells	Gas from a Vapor Phase Cracking Unit
Methane (and inerts)	93.62	53.04	63.8
Ethane	1.13	11.25	3.4
Ethylene	....	....	24.1
Propane	1.70	18.65	1.2
Propylene	....	....	5.2
Iso-butane	.57	3.30	.7
N-butane	.95	7.87	.4
Butene	....	....	.2
Iso-pentane	.42	2.35	....
N-pentane	.45	1.69	....
Hexanes and heavier	1.16	1.85	1.0

The following analysis of a Pennsylvania natural

gasoline shows that the paraffin hydrocarbons are the main constituents:

	Percent by Gas Volume
Propane	6
Butanes	14
Iso-pentane	13
N-pentane	17
Iso-hexane	9
N-hexane	15
Iso-heptane	8
N-heptane	12
Octane	4
Residue	2

Unsaturates are formed in the cracking and thermal polymerization processes. These unsaturates introduce a number of hydrocarbons having boiling points close to the boiling points of the paraffins, thus making the analysis more difficult. For example, the butane fraction of a cracked gas contains the following hydrocarbons:

Hydrocarbon	Boiling Point °C.	Boiling Point °F.
Iso-butane	—12.2	10
Iso-butene	— 6.8	19.8
N-butene 1	— 5.0	23
Butadiene	— 2.6	27.4
N-butane	— 0.3	31.5
Butene 2, trans	.9	33.6
Butene 2, cis	3.7	38.7

The analysis of such a complex mixture consists of isolating the butane fraction by means of a low-temperature distillation. The butane fraction is then subjected to a series of absorption analysis in various strengths of sulfuric acid. The butadiene is determined by absorption in maleic anhydride.

Composition of Gasolines

The United States Bureau of Standards has investigated the naphtha fraction from a sample of Kay County, Oklahoma, crude oil. The following hydrocarbons have been isolated and identified:

Paraffins Hydrocarbon	Boiling Point °F.	Percent in the Crude Oil
2, 3-Dimethylbutane	136	.04
2-Methylpentane	140	.09
3-Methylpentane	145.5	.18
n-Hexane	155	.50
2, 2-Dimethylpentane	174	.03
2-Methylhexane	194	.25
3-Methylhexane	197	?
n-Heptane	208.5	.90
2-Methylheptane	242.5	.5
n-Octane	258	1.0
Iso-nonane (2, 6-dimethylheptane?)	275	.1
Iso-nonane	284	?
2-Methyloctane	289	?
Iso-nonane (3-methyloctane)	292	?
N-Nonane	303	1.0
n-Decane	345	.8
Naphthenes		
Cyclopentane	122	?
Methylcyclopentane	162	.2
Cyclohexane	176	.3
1, 1-Dimethylcyclopentane	189	.04
Methylcyclohexane	212	.3
Octanaphthene	247	.2
1, 3-Dimethylcyclohexane	248	
Octanaphthene (1, 2-dimethylcyclohexane?)	254	.04
Ethylcyclohexane	269	.1
Nonanaphthene (alkyl cyclopentane)	277	.1
Aromatics		
Benzene	176	.08
Toluene	230	.3
Ethylbenzene	277	.03
p-Xylene	281	.04
m-Xylene	282	.12
o-Xylene	291	.12
Isopropylbenzene	307	.03
1, 3, 5-Trimethylbenzene	327	.02
1, 2, 4-Trimethylbenzene	336	.20
1, 2, 3-Trimethylbenzene	349	.06

By observing the small percentages of most of the hydrocarbons and the nearness of the boiling points one can better realize the number of hydrocarbons present in a crude oil and the difficulty of isolating them.

Cracking has a marked change in the nature of the hydrocarbons in the cracked gasoline. In general, it can be concluded that the higher the temperatures used in cracking, the lower will be the paraffin-hydrocarbon content of the cracked distillate, and conversely, the higher will be the aromatic and unsaturates content. The nature of the charging stock to the cracking unit has less effect on the chemical composition of the cracked distillate in vapor phase or high-temperature cracking than it does in low-temperature cracking.

Catalytic cracking produces a gasoline of high iso-paraffin content. The C_7 fraction from a catalytically cracked gasoline showed 89 percent of moderately branched hydrocarbons and 6 percent of highly branched hydrocarbons. The proportion of aromatics to olefins is also higher than with the conventionally cracked gasoline:

STOCK	Type of Cracking	Unsaturates	Aromatics	Naphthenes	Paraffins
Smackover crude...	Liquid-phase	15	28	21	36
Penn. crude	Liquid-phase	10	23	10	57
Mid-Cont. gas oil..	Vapor-phase	42	39	7	12
Mid-Cont. gas oil..	Vapor-phase	75	21	4	0

Kerosine

Rossini[3] in his API Research Project, has isolated some pure hydrocarbons from the kerosine fraction of a Mid-Continent crude oil:

	Percent by Volume of the 392 to 446 °F. Fraction
Normal paraffins	13.6
Aromatic hydrocarbons	19.1
Iso-paraffins and naphthenes	67.3

Some of the hydrocarbons isolated are shown:

	Percent by Volume of Distillate	Percent by Volume of Crude Oil
n-dodecane	13.6	1.0
1, 2, 3, 4-tetramethylbenzene	1.06	.078
5, 6, 7, 8-tetrahydronaphthalene	.27	.02
1-methyl-5, 6, 7, 8-tetrahydronaphthalene	.68	.05
naphthalene	.46	.034
1-methylnaphthalene	.84	.062

Lubricating Oils

The term "paraffin oil," "paraffin base," and "naphthene base" oil has indirectly led the layman to believe that lubricating oils refined from paraffin-base crudes contained considerable paraffin type of hydrocarbons. Today it is recognized that the straight-chain paraffins, originally present in a paraffin-base oil are removable as wax, leaving a viscous oil substantially free from paraffins.

The paraffin hydrocarbons present in a lubricating oil have lower viscosities than the oils in which they are dissolved. For example, when solvent refining a paraffin base stock:

	Charge	Raffinate	Extract
Gravity, A.P.I.	23.6	29.9	10.6
Viscosity Say. Universal @ 100 F	315	203	2768
Viscosity Say. Universal @ 210 F	50.2	47	76
Pour point	30	40	15

In the manufacture of medicinal white oils drastic refining with sulfuric acid greatly reduces the viscosity of the oil. These examples indicate that hydro-

carbons other than the paraffins account for the "base" of a lubricant.

The hydrocarbon structure is so complex and the number of hydrocarbons present in lubricating oils is so great that very little success has been had in isolating pure hydrocarbons therefrom. Several investigators have studied synthetic hydrocarbons and have made deductions regarding the chemical composition and nature of the heavy, viscous oils. Hugel[4] has concluded:

1. Ring formation has a great effect in increasing viscosity.

2. The branching chains in acyclic hyrocarbons has little or no effect on viscosity.

3. Unsaturation (olefins) has very little effect on viscosity in acyclic hydrocarbons, although it may be a factor in cyclic compounds.

4. In general, a cyclic nucleus in a molecule is necessary if such factors as branching of the chain or unsaturation are to have any effect on viscosity, and in acyclic compounds viscosity is materially increased only by increasing the molecular weight.

5. Of two oils with the same viscosity at a given temperature, say 100° F., the oil with the lower molecular weight is characterized by greater viscosity change with change in temperature.

Mikeska[5] states that the high viscosity indices of paraffin-base oils, which are assumed to have long side chains and are known to have a high ratio of paraffins to cyclic atoms in their molecular composition, led to an early conviction that the length of the side chains is the controlling factor affecting the viscosity index of an oil. It has been shown that the viscosity index of synthetic oils obtained by polymerization of olefins is dependent on the length of the olefinic molecule and that the longer the paraffinic chain of the original olefin, the higher the viscosity index of the resulting oil. These views were fully substantiated by the properties of the synthetic hydrocarbons prepared in this work. For instance the viscosity index of octadecyl naphthalene is 150, whereas the viscosity indices of the three tri-n-hexylnaphthalenes are only about 100. Similarly, the viscosity indices of docosamylnaphthalene, which has a chain of 22 carbon atoms, is 144, whereas the viscosity index of 1, 1-naphthyl-n-butyloctadecane with a chain of 18 carbon atoms is only 122, although they have the same number of paraffinic carbon atoms attached to the naphthalene ring.

Unsaturated hydrocarbons, as olefinic unsaturation, are present in lubricating oils but in small quantities. Sachanen estimated the proportion of unsaturates at 3-10 percent.

In another report on the research conducted at the National Bureau of Standards, Mair[6] made the following conclusions concerning the chemical constitution of the lubricating fraction of a Mid-Continent petroleum from which the wax and asphaltic constituents had been removed:

1. About 60 percent of the material consists of naphthenes with from one to three rings per molecule (a very small amount of material containing four naphthenic rings is probably present also).

2. About 15 percent of the material consists of molecules with one aromatic ring and from one to three naphthenic rings per molecule, and with this material is associated a small amount of sulphur and oxygen compounds.

3. About 14 percent of the material consists of molecules with two aromatic rings (linked through two common carbon atoms) and about two naphthenic rings per molecule, and with this material is associated a small amount of sulphur and oxygen compounds.

4. About 11 percent of the material consists of molecules with more than two aromatic rings (each probably linked through two common carbon atoms) and one or two naphthenic rings per molecule, and with this material are associated some sulphur, nitrogen and oxygen compounds.

By determining the mean molecular weight of a lubricating oil fraction and the amount of hydrogen it will absorb on hydrogenation with a nickel-kieselguhr catalyst the percentage of aromatic nucleus can be determined. By then determining the specific refraction of the hydrogenated product the proportion of naphthene rings to paraffinoid chains can be calculated from curves previously prepared from data derived from the refractivity-molecular weight relationship of known paraffins and simple and polynuclear naphthenes. It is possible in this way to compare a paraffin oil with a naphthene oil.

	Penn. Paraffin Oil	Naphthene-Base Oil
Molecular weight	512	349
Aromatic rings	8	32
Naphthenic rings	15	29
Paraffinic chains	77	39

It is not possible by this means to decide if the paraffinic chains are side chains attached to aromatics or naphthenic rings or whether they are separate purely paraffinoid hydrocarbons. The low melting point precludes the presence of normal paraffins.

Waxes

It has been assumed that commercial paraffin waxes consisted essentially of normal paraffins. Recent investigations show that some of the wax is composed of branched-chain paraffins. Some typical waxes removed from petroleum have the following properties:

Melting Point	185° F.	133° F.
Ave. molecular weight	741	525
Formula	$C_{53}H_{108}$	$C_{38}H_{78}$
Specific gravity	.943	.928
A.P.I. gravity	18.6	21.0
Absolute viscosity at 212 F	.101	.064

Asphalt

Asphalt is made up of the higher-molecular-weight hydrocarbons and contains all of the four general types, olefin, paraffin, naphthene, and aromatic. Because of the complex chemical nature of this heavy petroleum product, the constituents are generally divided into asphaltenes, resins, and oils. It is generally considered that asphalt is a stable colloidal emulsion dispersed in an oily constituent.

The asphaltenes content is determined by precipitation with petroleum ether. The resins are separated from the oily constituents by adsorption in charcoal or fuller's earth. The nature of the components of asphalt vary considerably. The properties of the asphalt depend not only on the type and quantity of each component but also on the effect that the three components have on each other.

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Multicomponent Distillation

Approximate Method for the Estimation of Concentration Gradient of Each Component Along the Plates

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IT IS found that the ratio of any two components on any plate can be expressed in terms of the ratio of the same pair of components in products or the bottoms, with the aid of the average values of the ratio of "relative volatility" and "relative operability." When a set of ratios on any plate is known, the mol fraction of each component on this plate can be calculated. The results check well with the more rigid and laborious stepwise method. An illustrative example is given.

IN A PREVIOUS article of this series,[5] the author has presented a graphical method for the stepwise calculations of multicomponent rectification. It is probably the quickest method for carrying out the detailed calculations. The advantage of a stepwise solution lies in the fact that it gives a complete picture of the concentration gradients of each component long the plates as well as the temperature on each plate. The inherent disadvantage of this method, however, is its stepwise nature, which, in the case of a large number of plates, is unavoidably, time-consuming. This paper presents a hop, step and jump method which is simple and quick and gives a complete picture of the concentration gradient of each component along the column with reasonable accuracy.

The Method

Gilliland[3] derived the following equations for multicomponent rectification:

$$\left(\frac{x_b}{x_c}\right)_{n-1} = \left(\frac{\alpha\, b-c}{\alpha\, b-c}\right)_n \left(\frac{x_b}{x_c}\right)_n \qquad (1)$$

The term α, designated by Fenske[2] as "relative volatility," is defined as:

$$(\alpha_{b-c})_n = \left(\frac{K_b}{K_c}\right)_n$$

where K_b and K_c are vapor-liquid equilibrium constants for components b and c respectively.

The term β, designated by Gilliland as "relative operability" is defined by the following equations:

Above the feed,

$$(\beta_{b-c})_n = \frac{1-\frac{P}{O_{n-1}}\left(\frac{(x_b)_P}{(x_b)_{n-1}}\right)}{1-\frac{P}{O_{n-1}}\left(\frac{(x_c)_P}{(x_c)_{n-1}}\right)}$$

Below the feed plate,

$$(\beta_{b-c})_m = \frac{1-\frac{W}{O_{m-1}}\left(\frac{(x_b)_W}{(x_b)_{m-1}}\right)}{1-\frac{W}{O_{m-1}}\left(\frac{(x_c)_W}{(x_c)_{m-1}}\right)}$$

Expressing the ratio of mol fractions of any two components in liquid on the top plate in terms of that of the product, we have, for the case of a total condenser:

$$\left(\frac{x_b}{x_c}\right)_P = (\alpha_{b-c})_t \left(\frac{x_b}{x_c}\right)_t \qquad (2)$$

Expressing the same ratio on the plate next from the top plate, i.e., plate No. t-1, in terms of that of the product, we have

$$\left(\frac{x_b}{x_c}\right)_{t-1} = \left(\frac{x_b}{x_c}\right)_P \frac{1}{(\alpha_{b-c})_t} \frac{1}{\left(\frac{\alpha_{b-c}}{\beta_{b-c}}\right)_{t-1}} \qquad (3)$$

Similarly, for plate t-2,

$$\left(\frac{x_b}{x_c}\right)_{t-2} = \left(\frac{x_b}{x_c}\right)_P \frac{1}{(\alpha_{b-c})_t} \frac{1}{\left(\frac{\alpha_{b-c}}{\beta_{b-c}}\right)_{t-1}} \frac{1}{\left(\frac{\alpha_{b-c}}{\beta_{b-c}}\right)_{t-2}} \qquad (4)$$

For the n-th plate from the top plate, we have

$$\left(\frac{x_b}{x_c}\right)_{t-n} = \left(\frac{x_b}{x_c}\right)_P \frac{1}{(\alpha_{b-c})_t} \frac{1}{\left(\frac{\alpha_{b-c}}{\beta_{b-c}}\right)_{t-1} \cdots \left(\frac{\alpha_{b-c}}{\beta_{b-c}}\right)_{t-n}} \qquad (5)$$

Or, if an average value of $\frac{\alpha}{\beta}$ is selected, the above equation is simplified to

$$\left(\frac{x_b}{x_c}\right)_{t-n} = \left(\frac{x_b}{x_c}\right)_P \frac{1}{(\alpha_{b-c})_t} \frac{1}{\left[\left(\frac{\alpha_{b-c}}{\beta_{b-c}}\right)_{ave}\right]^n} \qquad (6)$$

For other condenser conditions, a material balance around the condenser and the top plate can be made first and Equation (6) applied accordingly.

For the section below the feed plate, we have

$$\left(\frac{x_b}{x_c}\right)_{W+1} = \left(\frac{\alpha_{b-c}}{\beta_{b-c}}\right)_W \left(\frac{x_b}{x_c}\right)_W \qquad (7)$$

and,

$$\left(\frac{x_b}{x_c}\right)_{W+1} = \left(\frac{\alpha_{b-c}}{\beta_{b-c}}\right)_W \left(\frac{\alpha_{b-c}}{\beta_{b-c}}\right)_{W+1} \left(\frac{x_b}{x_c}\right)_W \qquad (8)$$

For the m-th plate above the still, we have, using an average value of $\frac{\alpha}{\beta}$ for this section:

$$\left(\frac{x_b}{x_c}\right)_{W+m} = \left(\frac{\alpha_{b-c}}{\beta_{b-c}}\right)^m \left(\frac{x_b}{x_c}\right)_W \qquad (9)$$

If there are N components appearing in the dis-

tillate and their mol fractions are known, a reference component c can be chosen and N-1 equations similar to (6) can be written, each for the ratio of the mol fraction in liquid of one component to that of the reference component.

For feed-plate composition, Brown's modification[1] of Lewis and Mathesons' method can be used. From the estimated feed-plate composition and temperature, the 'α's and 'β's for each set of ratios of 'x's on the feed plate can be easily calculated. From the arithmetical mean of 'α top plate' and 'α feed plate,' α_{ave} is obtained. From the arithmetical mean of 'β top plate' and 'β feed plate,' β_{ave} is obtained. Thus $\left(\frac{\alpha}{\beta}\right)_{ave}$ for the upper section is obtained. Known this value, Equation (6) can be easily applied to determine the ratios of 'x's on any plate of the upper section of the column.

Given the values of a set of ratios on any plate, we have

$$\frac{x_a}{x_c} + \frac{x_b}{x_c} + \frac{x_d}{x_c} + \cdots \frac{x_N}{x_c} + \frac{x_c}{x_c} = \frac{1}{x_c}$$

or,

$$x_c = \frac{1}{\Sigma\left(\frac{x}{x_c}\right)} \qquad (10)$$

Thus x_c can be easily calculated when $\frac{x_a}{x_c}$, $\frac{x_b}{x_c} \cdots \frac{x_N}{x_c}$ are known. Known the values of x_c and the ratios, x_a, $x_b \ldots x_N$ can be easily calculated by simple multiplication.

For the section below the feed, the technique is identical.

Known the concentrations of each component along the plates, it is a simple matter to match the plot of 'x' vs. plate number in the upper section with the similar plot for the lower section so that the curves come together. The number of plates required for each section are thus determined and the assumed value of feed-plate temperature can be checked by assuming a linear temperature gradient along the entire column. However, the average values of $\frac{\alpha'}{\beta}$s are rather insensitive to the error introduced by incorrectly assumed feed-plate temperature or composition that a second trial is usually unnecessary.

Illustrative Example

The benzene-toluene-xylene problem solved by Robinson and Gilliland[4] by stepwise method is taken for illustration. The set up of the problem is as follows:

	Feed Mols.	DISTILLATE		RESIDUE	
		Mols.	Mol. Fraction	Mols.	Mol. Fraction
Benzene	60	59.8	0.995	0.20	0.005
Toluene	30	0.30	0.005	29.7	0.744
Xylene	10	0	....	10.0	0.251
	100	D=60.1	1	W=399.9	1

$\frac{O}{D} = 2$ $\quad O_n = 120.2 \quad V_n = 180.3 = V_m$
$\quad O_m = 220.2$

Pressure = 760 mm. of Hg
Temperature at top = 80° C.
Temperature at still = 116° C.

The feed plate temperature is assumed to be 90° C. The values of 'α's are tabulated as follows:

	Temp. °C.	$\alpha_{B\text{-}T}$	$(\alpha_{B\text{-}T})_{ave}$	$\alpha_{X\text{-}T}$	$\alpha(_{X\text{-}T})_{ave}$
Top plate	80	2.62	2.54	0.40	0.405
Feed plate	90	2.46	2.41	0.41	0.425
Still	116	2.36		0.44	

The values of 'K's are

$$(K_f)_B = 1.33$$
$$(K_f)_T = 0.533$$
$$(K_f)_X = 0.221$$

Thus the feed plate composition is estimated as follows:

For benzene, $(x_f)_B = \frac{(P/V)\,(x_P)_B}{(K_f)_B - (O/V)_n} = \frac{0.995\ \frac{60.1}{180.3}}{1.33 - \frac{120.2}{180.3}} = 0.501$

For xylene, $(x_f)_X = \frac{(W/V_m)\,(x_W)_X}{\frac{O_m}{O_m} - (K_f)_X} = \frac{\frac{39.9}{180.3}\ 0.251}{1.221 - 0.221} = 0.556$

By difference, we have for toluene $(x_f)_T = 1 - 0.501 - 0.0556 = 0.443$

Different values of β are thus calculated as follows:
Above feed plate:

$$(\beta_{B\text{-}T})_{condenser} = \frac{1 + \frac{P}{O}(K_B)_{condenser}}{1 + \frac{P}{O}(K_T)_{condenser}} = \frac{1 + 0.33\,(0.994)}{1 + 0.33\,(0.374)} = 1.185$$

$$(\beta_{B\text{-}T})_{feed\ plate} = \frac{1 + 0.333\,\frac{0.995}{0.501}}{1 + 0.333\,\frac{0.005}{0.444}} = 1.656$$

$$(\beta_{B\text{-}T})_{ave,\ upper\ section} = 1.42$$

Similarly,

$$(\beta_{X\text{-}T})_{condenser} = \frac{1 + 0.333\,(0.151)}{1 + 0.333\,(0.374)} = 0.936$$

$$(\beta_{X\text{-}T})_{feed\ plate} = \frac{1 + 0.333\,\frac{0}{0.0555}}{1 + 0.333\,\frac{0.005}{0.444}} = 0.996$$

$$(\beta_{X\text{-}T})_{ave,\ upper\ section} = 0.966$$

Below feed plate:

$$(\beta_{B\text{-}T})_{feed\ plate} = \frac{1 - \frac{39.9}{220.2}\,\frac{0.005}{0.501}}{1 - \frac{39.9}{220.2}\,\frac{0.744}{0.444}} = 1.433$$

$$(\beta_{B\text{-}T})_{still} = \frac{1 - W/O_{m-1}\,\frac{1}{(K_B)_{still}}}{1 - W/O_{m-1}\,\frac{1}{(K_T)_{still}}} = \frac{1 - \frac{39.9}{220.2}\,\frac{1}{2.63}}{1 - \frac{39.9}{220.2}\,\frac{1}{2.25}} = 1.014$$

$$(\beta_{B\text{-}T})_{ave,\ lower\ section} = 1.2235$$

Similarly,

$$(\beta_{X\text{-}T})_{feed\ plate} = \frac{1 - \frac{39.9}{220.2}\,\frac{0.251}{0.0555}}{1 - \frac{39.9}{220.2}\,\frac{0.744}{0.4435}} = 0.260$$

$$(\beta_{X\text{-}T})_{still} = \frac{1 - \frac{39.9}{220.2}\,\frac{1}{0.513}}{1 - \frac{39.9}{220.2}\,\frac{1}{1.13}} = 0.772$$

$$(\beta_{X\text{-}T})_{ave,\ lower\ section} = 0.516$$

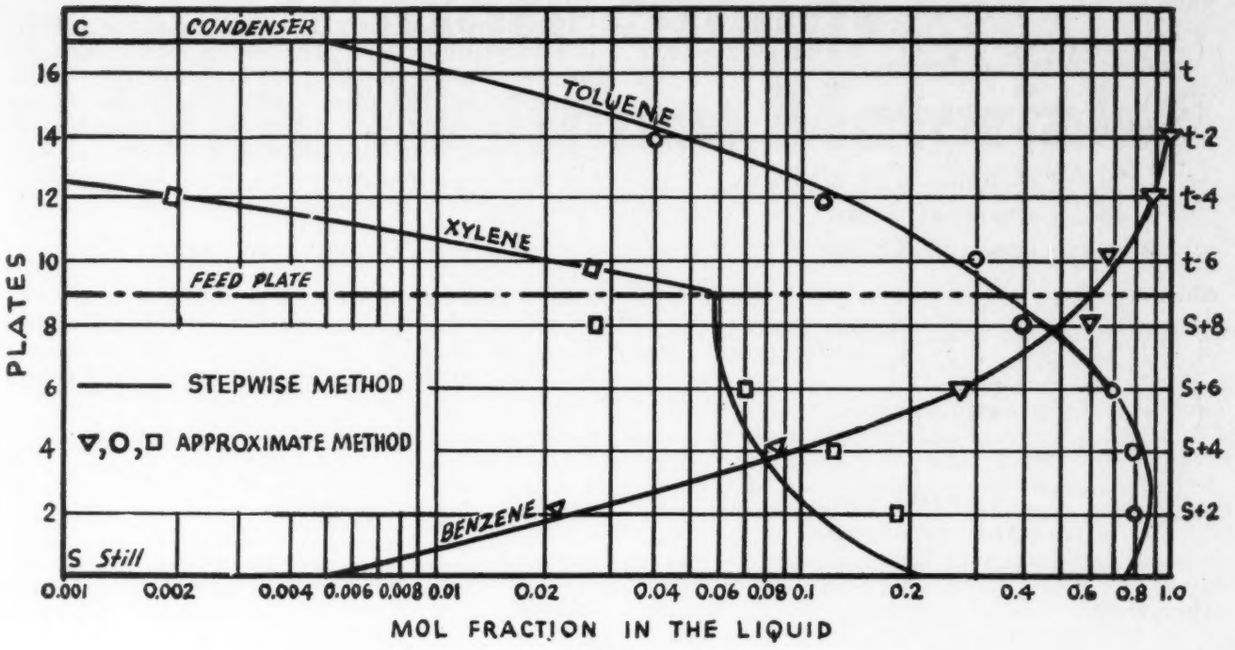

FIGURE 1

The values of $\left(\frac{\alpha}{\beta}\right)_{ave}$ are summarized as follows:

Above feed plate:

$$\left(\frac{\alpha_{B\text{-}T}}{\beta_{B\text{-}T}}\right)_{ave} = \frac{2.54}{1.421} = 1.787$$

$$\left(\frac{\alpha_{X\text{-}T}}{\beta_{X\text{-}T}}\right)_{ave} = \frac{0.405}{0.966} = 0.419$$

Below feed plate:

$$\left(\frac{\alpha_{B\text{-}T}}{\beta_{B\text{-}T}}\right)_{ave} = \frac{2.405}{1.224} = 1.97$$

$$\left(\frac{\alpha_{X\text{-}T}}{\beta_{X\text{-}T}}\right)_{ave} = \frac{0.425}{0.516} = 0.823$$

Thus the concentration of any component on any plate can be calculated by the use of Equations (6), (9), and (10).

Above feed plate:

when n = 2,

$$\left(\frac{x_B}{x_T}\right)_{t-2} = \left(\frac{x_B}{x_T}\right)_P \frac{1}{(\alpha_{B\text{-}T})_t} \frac{1}{\left(\frac{\alpha_{B\text{-}T}}{\beta_{B\text{-}T}}\right)^2_{ave}}$$

$$= \frac{0.995}{0.005}\,\frac{1}{2.62}\,\frac{1}{0.419^2} = 23.8$$

$$\left(\frac{x_X}{x_T}\right)_{t-2} = \frac{10^{-7}}{0.005}\,\frac{1}{0.40}\,\frac{1}{0.419^2} = .0029$$

$$\therefore \quad (x_T)_{t-2} = \frac{1}{1 - 23.8 - 0.0029} = 0.040$$

$$(x_B)_{t-2} = 23.8\ (0.040) = 0.960$$

$$(x_X)_{t-2} = .0029\ (0.040) = 0.0001$$

when n = 4,

$$\left(\frac{x_B}{x_T}\right)_{t-2} = \left(\frac{x_B}{x_T}\right)_{t-2} \frac{1}{\left(\frac{\alpha_{B\text{-}T}}{\beta_{B\text{-}T}}\right)^{4-2}_{ave}} = 7.45$$

$$\left(\frac{x_X}{x_T}\right)_{t-2} = \left(\frac{x_X}{x_T}\right)_{t-2} \frac{1}{\left(\frac{\alpha_{X\text{-}T}}{\beta_{X\text{-}T}}\right)^2_{ave}} = 0.016$$

$$(x_T)_{t-4} = \frac{1}{1 - 7.45 - 0.016} = 0.118$$

$$(x_B)_{t-4} = 0.118\ (7.45) = 0.879$$

$$(x_X)_{t-4} = 0.118\ (0.016) = 0.0019$$

when n = 6,

$$\left(\frac{x_B}{x_T}\right)_{t-6} = \left(\frac{x_B}{x_T}\right)_{t-4} \frac{1}{\left(\frac{\alpha_{B\text{-}T}}{\beta_{B\text{-}T}}\right)^{6-4}_{ave}} = 2.332$$

$$\left(\frac{x_X}{x_T}\right)_{t-6} = \left(\frac{x_X}{x_T}\right)_{t-4} \frac{1}{\left(\frac{\alpha_{X\text{-}T}}{\beta_{X\text{-}T}}\right)^2_{ave}} = 0.0916$$

$$\therefore \quad (x_T)_{t-6} = \frac{1}{1 - 2.332 - 0.0916} = 0.292$$

$$(x_B)_{t-6} = 0.292\ (2.332) = 0.677$$

$$(x_X)_{t-6} = 0.292\ (.0916) = 0.0268$$

Below feed plate:

when m = 2,

$$\left(\frac{x_B}{x_T}\right)_{W+2} = \left(\frac{\alpha_{B\text{-}T}}{\beta_{B\text{-}T}}\right)^2_{ave} \left(\frac{x_B}{x_T}\right)_W = 1.97^2\,\frac{0.005}{0.744} = 0.0262$$

$$\left(\frac{x_X}{x_T}\right)_{W+2} = 0.823^2\,\frac{0.251}{0.744} = 0.2287$$

$$\therefore \quad (x_T)_{W+2} = \frac{1}{1 - 0.0262 - 0.2287} = 0.797$$

$$(x_B)_{W+2} = 0.797\ (0.0262) = .0208$$

$$(x_X)_{W+2} = 0.797\ (0.2287) = 0.182$$

(Continued on next page)

when $m = 4$,

$$\left(\frac{x_B}{x_T}\right)_{w+4} = \left(\frac{x_B}{x_T}\right)_{w+2}\left(\frac{\alpha_{B-T}}{\beta_{B-T}}\right)^2_{ave} = .0262\ (1.97)^2 = 0.1014$$

$$\left(\frac{x_X}{x_T}\right)_{w+4} = 0.2287\ (0.823)^2 = 0.155$$

$$\therefore\quad (x_T)_{w+4} = \frac{1}{1 - 0.1014 - 0.155} = 0.796$$

$$(x_B)_{w+4} = 0.796\ (0.1014) = .0809$$

$$(x_X)_{w+4} = 0.796\ (0.155) = 0.1235$$

when $m = 6$,

$$\left(\frac{x_B}{x_T}\right)_{w+6} = \left(\frac{x_B}{x_T}\right)_{w+4}\left(\frac{\alpha_{B-T}}{\beta_{B-T}}\right)^2_{ave} = 0.1014\ (1.97)^2 = 0.394$$

$$\left(\frac{x_X}{x_T}\right)_{w+6} = 0.155\ (0.823)^2 = 0.105$$

$$\therefore\quad (x_T)_{w+6} = \frac{1}{1 - 0.394 - 0.105} = 0.667$$

$$(x_B)_{w+6} = 0.667\ \ (0.394) = 0.263$$

$$(x_X)_{w+6} = 0.667\ \ (0.105) = 0.070$$

when $m = 8$,

$$\left(\frac{x_B}{x_T}\right)_{w+8} = \left(\frac{x_B}{x_T}\right)_{w+6}\left(\frac{\alpha_{B-T}}{\beta_{B-T}}\right)^2_{ave} = 0.394\ (1.97)^2 = 1.53$$

$$\left(\frac{x_X}{x_T}\right)_{w+8} = 0.105\ \ (0.823)^2 = 0.0712$$

$$\therefore\quad (x_T)_{w+8} = \frac{1}{1 - 1.53 - 0.0712} = 0.384$$

$$(x_B)_{w+8} = 0.384\ \ (1.53) = 0.588$$

$$(x_X)_{w+8} = 0.384\ \ (.0712) = 0.027$$

The results are plotted on Figure 1.

It is found that the points check with the stepwise data surprisingly well. The use of logarithmic plotting has greatly amplified the errors for the concentrations of xylene on the lower section of the column; which, in the present case, is of little significance. The number of plates above feed is found to be 7, and the total number of plates including the still, 17. Thus the feed plate temperature would be

$$T = 80 - \frac{7}{17}(116 - 80) = 94.8^\circ\ C.$$

This is quite far off from the assumed value of 90° C. This shows that the present method is rather insensitive to the error introduced by the incorrect assumption made on the feed plate temperature and composition.

Nomenclature

x = mole fraction in liquid
y = mole fraction in vapor
O = moles of overflow
P = moles of distillate
V = moles of vapor
W = moles of bottoms
K = vapor-liquid equilibrium constant.

Subscripts:

n = section above feed
m = section below feed
f = feed plate
w = still
t = top plate
B = Benzene
T = Toluene
X = Xylene

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More Steam With Minimum Materials

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THE present scarcity of raw materials has made it difficult, if not impossible, to secure additional steam for increasing refinery requirements by the installation of new boilers of conventional design. Therefore when an increase in total steam production is needed, new ways of accomplishing this by the use of a minimum amount of critical material must be devised. Furthermore, as this additional steam requirement may end at the termination of the war, it is essential that the cost of the steam-generating equipment be kept to a minimum. Some methods of doing this have already been developed, but there are also new ways which are worthy of consideration. Methods which may be used in existing refinery equipment will be considered first.

Use of Waste Heat Boilers

In many refineries, especially those located where fuel is cheap, no waste heat equipment is installed to recover heat from the gases leaving the still. In such cases a considerable amount of steam can be produced at no additional fuel cost, by the installation of waste-heat boilers on the existing still. Figure 1 shows an installation of this nature that has been in successful operation for over two years. The gases after leaving the convection oil-heating section of the double-end heater pass through an underground flue to an auxiliary furnace and thence to a waste-heat boiler. In this particular installation, the horizontal boiler tubes are of the well-known extended surface type consisting of bare tubes encased in cast iron annular rings. Details of this tube construction are shown in Figure 2. The auxiliary furnace is equipped with burners so that by their operation steam can be generated when the still itself is out of service. Also the total amount of steam generated from the heat in the waste gases can be further increased by operating the burners in the auxiliary furnace even when the still is in operation. The following figures give an indication of the quantity of steam that can be generated. Without any auxiliary firing 25.5 percent of the heat input to the oil can be recovered in steam generation. When operating the auxiliary burners and burning in them 14.1 of the fuel fired in the main still, the total heat in the form of steam generated can be increased to 44.5 percent of the heat absorbed in the oil.

Combination Direct-Fired Boiler and Still

In many cases the quantity of steam generated from waste-heat boilers, even using auxiliary firing, is not sufficient for the refinery requirements. In such cases additional steam may be obtained by installing radiant boiler tubes in the furnace of an existing oil still. Figures 3 and 4 show how this can be done in an existing double end heater. This heater has radiant oil tubes in the roof and in both side walls of both furnaces. Panels of radiant boiler tubes could be placed on both sides of the oil burners in all four end walls of the two furnaces. Additional radiant boiler tubes could be put in the floor coming in at the end, and brought up at the center of the furnace to the steam drum above. To further increase the amount of steam produced, a waste-heat boiler could be installed utilizing the same steam drum as the radiant boiler.

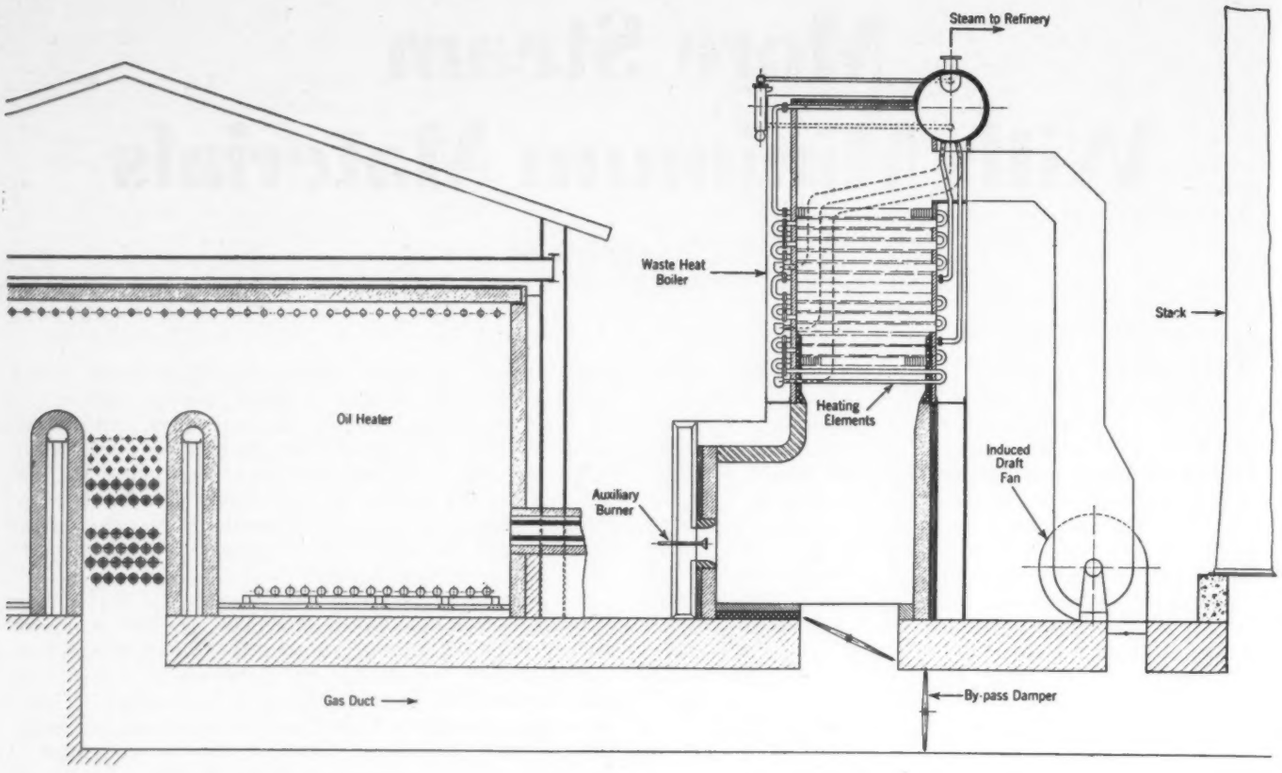
As originally installed this particular heater was designed for a heat input of 62,000,000 Btu per hour to the oil. By putting in radiant and waste-heat boiler surface, an additional 25,000,000 Btu per hour can be put into steam, which is equivalent to produce approximately 25,000 pounds of steam per hour. About 7,000 pounds per hour of this is recovered in the waste-heat boiler and about 18,000 pounds per hour in the radiant boiler. The overall efficiency of the combination boiler and still operating with 10 percent CO_2 would be 80 percent.

The use of a waste-heat boiler will probably necessitate the installation of induced draft fan equipment. In localities where fuel is cheap and the heat recovered by the waste-heat boiler would not justify its first cost, it would be possible to install a radiant boiler only and possibly continue to operate on natural draft with the existing stack.

In cases where a radiant boiler is put into an existing still, a considerable amount of steam could be generated without increasing the heat absorption in the oil tubes because the additional radiant steam surface absorbs the additional heat available by radiation due to lower excess air and higher firing rate. Where the quantity of steam required will mean heat releases in the existing furnace which will give higher than permissible heat absorption in the radiant oil tubes, these tubes may be screened by radiant boiler tubes. A design for doing this is shown in Figure 5. Radiant boiler tubes are placed in front of the oil tubes in the side walls and the roof. By proper location and spacing of these water tubes, the heat absorption in the oil tubes may be kept at the proper rate even when operating with a minimum amount of excess air and high liberation per cubic foot of furnace volume. In other words, additional fuel may be fired in the existing furnace without increasing the heat absorption in the oil tubes, beyond that called for in the initial design. This screening of oil tubes in the furnace by radiant boiler tubes might also be beneficial in heating an oil which is particularly sensitive to localized overheating.

Savings in First Cost and Material

Definite saving in material and first cost can be made by installing steam generating surface in combination with an oil heater, as compared with the cost of a separate direct-fired boiler and an oil heater.



Arrangement of oil heating furnace, underground gas flue, waste heat boiler, induced draft fan and stack. Dampers are shown in the flues; for normal operation the main by-pass damper is closed, as shown, while the damper leading into the waste heat boiler, and the damper below the induced draft fan, are open.

This application of waste heat boilers utilizes the heat in flue gases from the oil heaters for generating steam for the distilling unit, making the unit independent of a central boiler station and long steam lines. The auxiliary burner permits increasing steam production if desired and the raising of steam to put the unit into service.

The cast iron extended heating surface of the waste heat boilers has six times the heat absorbing surface of bare tubes and greatly higher resistance to corrosion.

FIGURE 1

Without going into detailed comparison, a single boiler unit to give 100,000 pounds of steam per hour is cheaper than two 50,000-pound-per-hour units. On the same basis, if 50,000,000 Btu per hour is put into oil and 25,000,000 Btu per hour into steam, a combined unit is cheaper in first cost, and in material required, than a separate oil heater and boiler for the same capacities.

Steam for New Oil Units

Just as there are savings in material and cost by combining the heating of oil and the generation of steam in an existing oil heater, there are comparable or even greater savings when putting in a new refining unit. The design of the combination boiler and still can be better met if the two problems can be considered in the initial design of the heater. Where it is decided to heat oil and generate steam in a combined heater, it is often advisable to generate sufficient steam for all process and power requirements of the new unit. This will necessitate ability to generate steam for the operation of oil-charging pumps, fans, etc., before the still itself is in operation. One design which will permit of this is shown in Figure 6. With this design the oil heating is done in an upshot heater with radiant oil tubes on both sides of the furnace. Upon leaving the furnace the gases pass over a steam superheater and then through a convection oil-heating bank. The gases then pass through a vertical bare tube, two-drum waste-heat boiler. An auxiliary furnace is placed on the right side of the waste-heat boiler. To obtain steam for starting up the unit, burners are lighted in the auxiliary furnace. Gases from this furnace enter the waste-heat boiler and are drawn through and out to an induced draft fan. In this way steam may be gen-

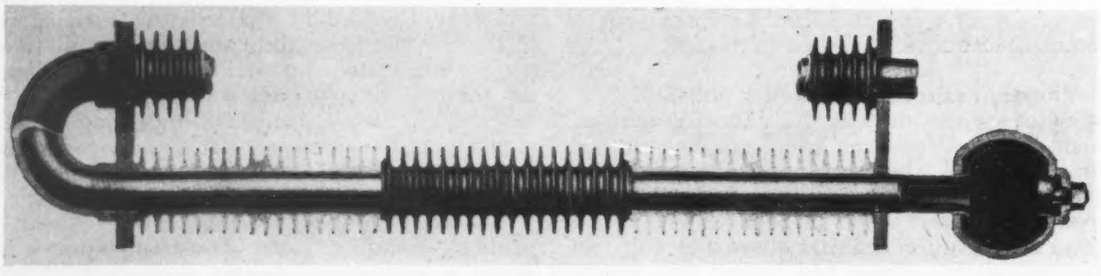
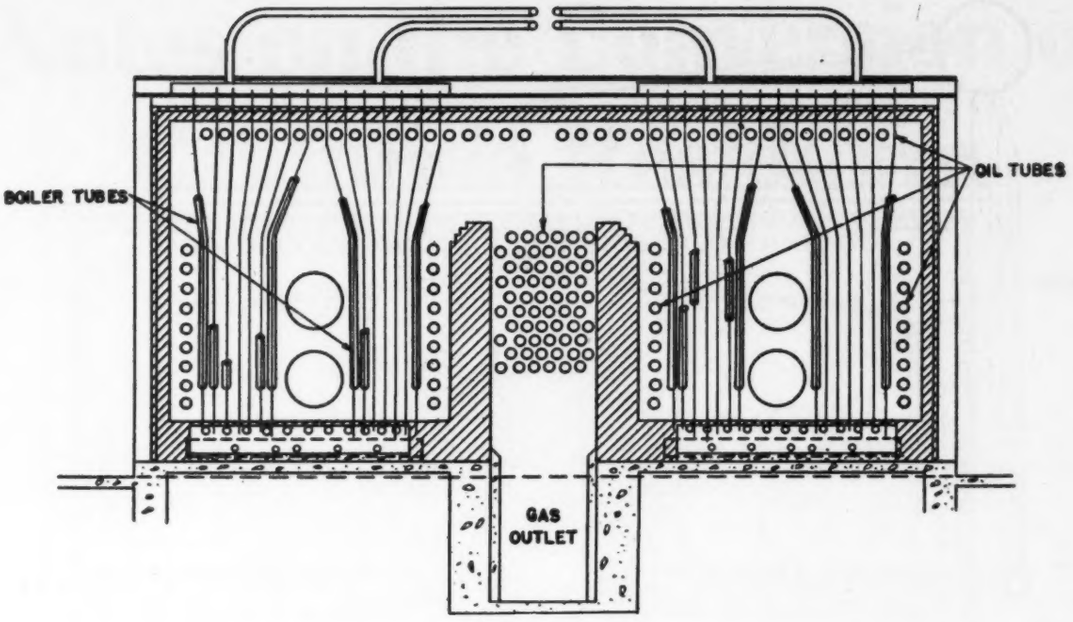


FIGURE 2



SECTION "A-A"

FIGURE 3

Conversion of existing oil heater to a combination steam boiler-oil heater

erated for starting up without operating the furnace of the oil heater. As indicated on the drawing, additional steam is generated by radiant boiler tubes which are placed in front of the oil tubes in the side walls of the furnace and are also put into the floor. The boiler tubes shown behind the radiant oil tubes are on very wide centers. Their purpose is not for heat absorption but to support the oil tubes and eliminate the use of costly alloy supports. This cut shows the adoption of a radiant and waste-heat boiler to one type of heater. Designs similar in basis have been worked out for other types of heaters.

Improved Efficiency in Oil Heating

Many existing stills operate with from 50 to 100 percent excess air and with consequent low fuel efficiency. The use of such large quantities of excess air is for two reasons:

1. To reduce furnace temperature so that heat absorption of the radiant oil tubes will not be above a safe limit.

2. So that the temperature of the gases entering the convection bank will not result in too high a heat absorption in the first few rows of tubes.

Putting additional black surface in the furnace in the form of radiant boiler tubes, increases the furnace cooling factor and makes it possible to materially reduce the excess air used and at the same time to get higher overall efficiency without danger of overheating either in the radiant or convection oil tubes.

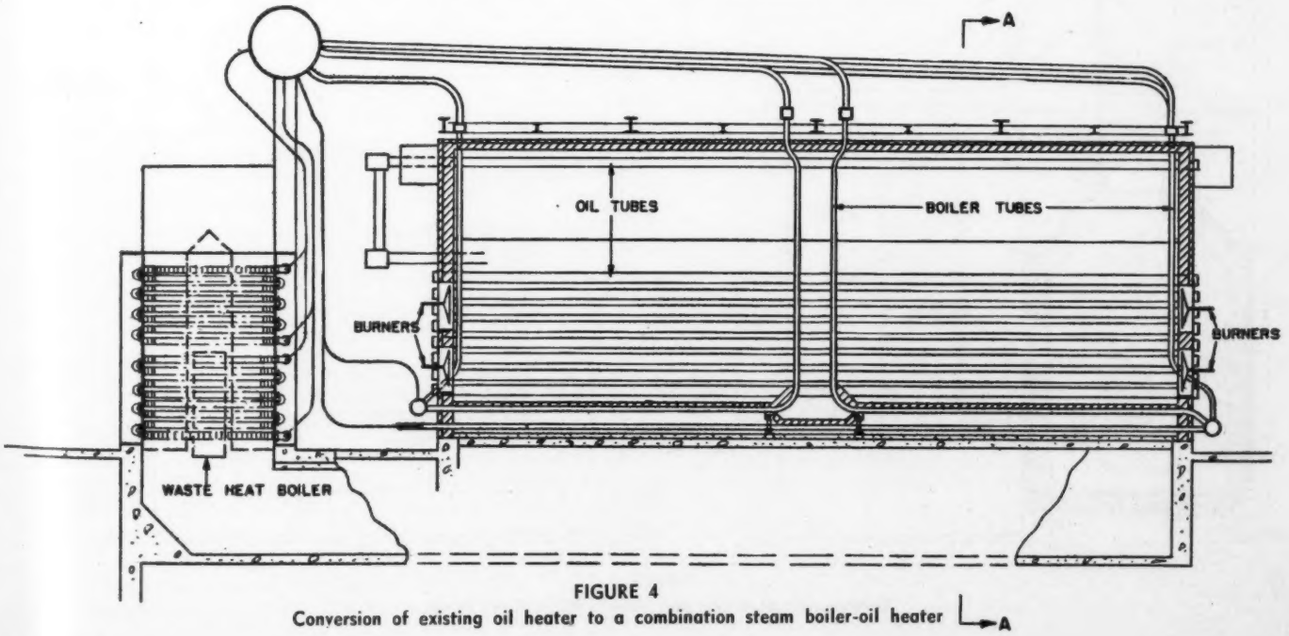


FIGURE 4

Conversion of existing oil heater to a combination steam boiler-oil heater

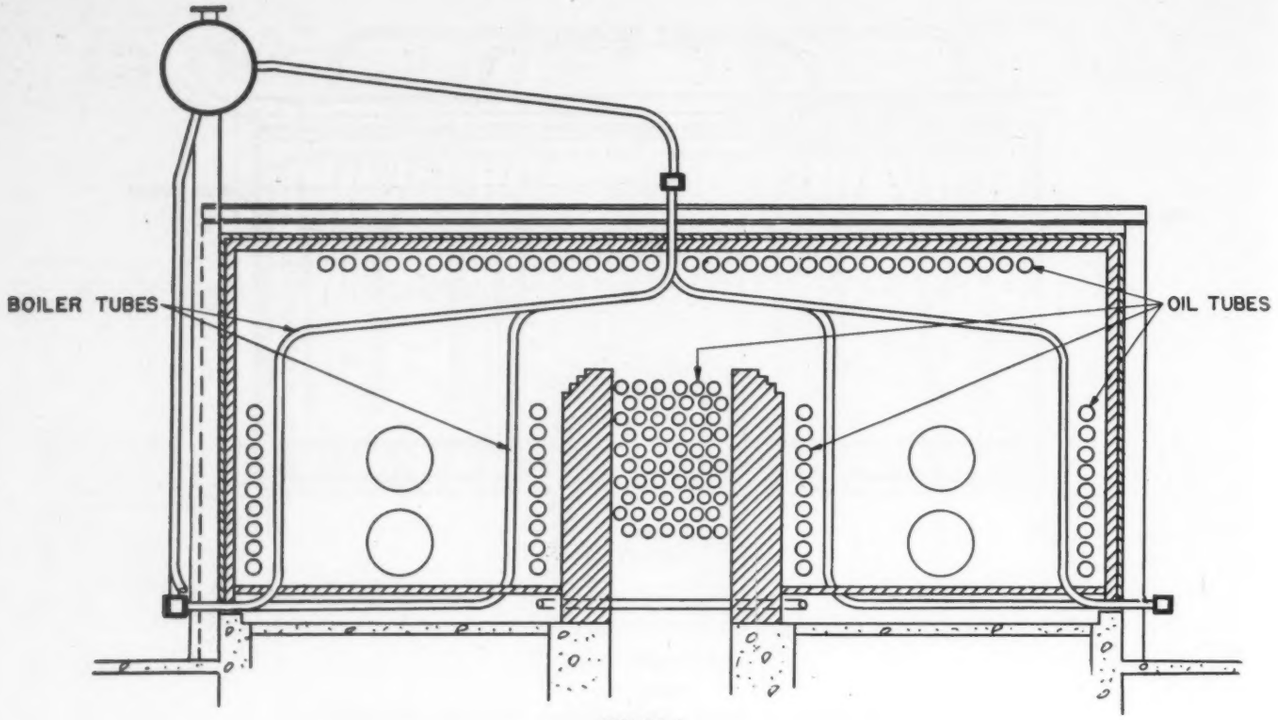


FIGURE 5
Method of controlling heat absorption in oil tubes in combination boiler-heater

Conclusion

Heating oil and generating steam in the furnace of an oil heater has the following advantages:

1. The first cost of the steam-generating and oil-heating equipment is reduced.
2. The total material required for steam generation is reduced.
3. Steam can be generated with the same efficiency as in a separate, direct-fired boiler plant.
4. The efficiency of heating the oil can be increased.
5. Auxiliary motor drives can be eliminated.

When both steam and power come from a central power plant, auxiliaries such as pumps, fans, etc., are usually arranged for both steam and motor drive.

With a combination boiler and still, the motor drives can be omitted as steam will always be generated when the still is in operation.

6. Large savings in first cost and material in elimination of steam and power lines from power station to refinery unit location.

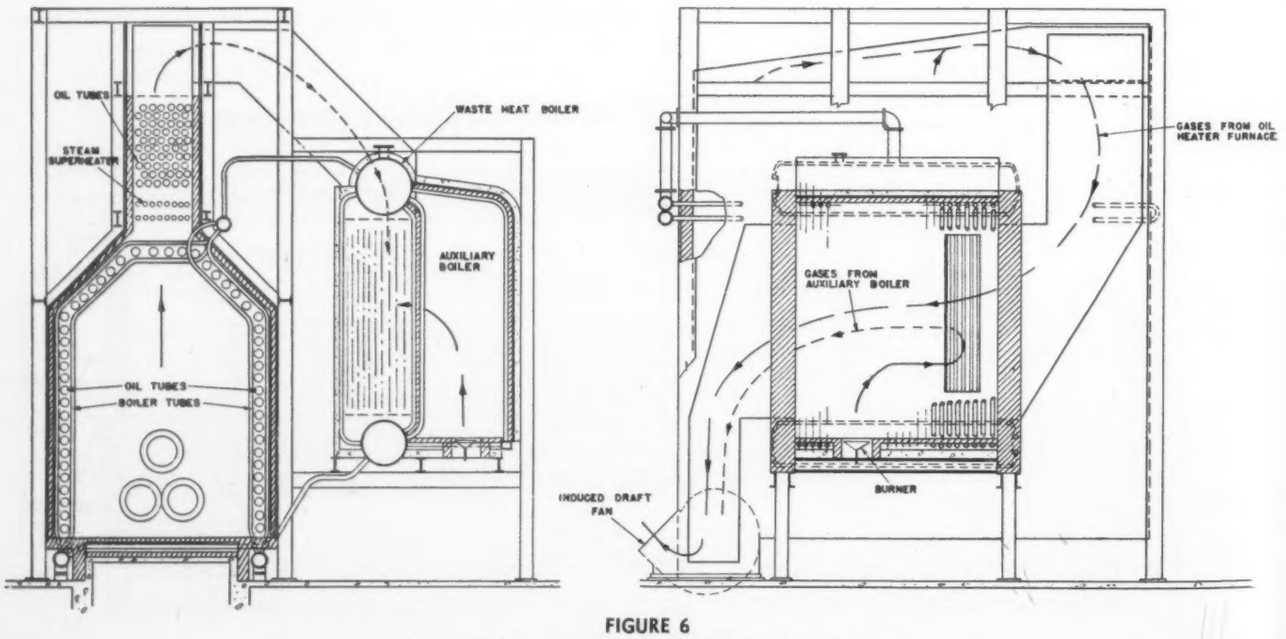


FIGURE 6
Combination oil heater and boiler with auxiliary furnace

Notes on the Conversion of California Residuum

ROBERT F. NAEVE

THE primary objective in my first experiments in the conversion of crude residuum to the lighter hydrocarbons was gasoline and diesel oil. However, after conducting a test for Dr. L. Stabler, then Dean of Chemistry of the University of Southern California, and making an analysis of all products, his recommendations were to concentrate on the possibilities of the process along the lines of the diesel oil and products for chemical manufacturers. Following his advice I have turned my attention to the production of the unsaturates suitable for chemical industries, a coke suitable for the steel industry, and a high-grade, low-compression, diesel fuel. The latter product particularly interested me for I believe that a light-weight, low-compression two-cycle diesel motor will shortly become an important factor in the automotive and aviation industries.

Basing my conclusions on the chemical construction of crude petroleum, and believing that excessive pressure and temperature break down the basic molecular construction of the various components, causing excessive carbonization and undesirable recombinations, I decided that a chemical catalyst could be used to offset pressure and temperature and still bring about the desired decomposition and recomposition.

In developing the process, I found that a number of factors enter into the conversion of high-boiling hydrocarbons, namely, the metal used in the construction of the reaction chambers, the design of the unit and its size in relation to throughput volume, and still more important, the maintenance of exact temperatures. These, in conjunction with the use of a certain type of catalyst, present a multitude of possibilities.

The importance of design in reaction chamber is illustrated by an experiment conducted with one type of unit, using 17-gravity residuum and a strong alkali compound catalyst with a pressure of 125 pounds and a temperature of 750° F. This produced 83 percent of total charge of 44.7-gravity distillate; on redistillation produced 52.33 percent of 54.1-gravity gasoline; 24.33 percent kerosine, 39-gravity; 19.66 percent of 32.6-gravity bottoms. Then in a unit of different design, using the same kind of oil and catalyst, the same temperature and pressure, it was almost impossible to get any reaction and the result was a very poor test.

The first cycle of the process is the segregation of the asphalt-like components representing an overbalancing of the carbon molecules. With the carbon molecule having a valence of four, compared to that of hydrogen with one, it seemed reasonable to assume that in the field of atomic attraction, carbon has a greater attraction than hydrogen. Therefore, to eliminate the carbonaceous matter from the sphere of action as fast as it forms (as in this case the carbon acts as a negative catalyst) results in the production of a distillate practically free from carbon. The amorphous carbon formed during the operation migrates with the hydrogen to create a more proper ratio of carbon and hydrogen atoms. Following this operation, one can proceed along the line best suited to that which one wishes to produce.

The bottoms from the first cycle I have used in

BECAUSE of the status of his experimental work the author was forced to omit some pertinent data from these notes on conversion of heavy residuum to lighter hydrocarbons.

Some of his findings, however, are of such nature that he wished to bring them to the attention of other men who may be proceeding along similar lines. This manuscript resulted from correspondence in which the author asked concerning this possibility.

Correspondence would be directed to Robert F. Naeve, 1418 East Fifteenth Street, Long Beach, California.

Tabulation of Average Test Run of Signal Hill Topped Crude

17.2 gravity, size of reaction chamber 18 inches diameter, height, 4 feet, 9 inches, maximum temperature—750° F., maximum pressure—75 lbs. Time to bring to temperature, 45 minutes. Rate of recovery, 1 gallon per minute. Recovery of pressure distillate, 83 percent of 33.5 gravity.

Recovery of Original Charge	Percent
Gasoline Distillate	20
Diesel	63
Fuel or rerun stock	13
Wet gas	3
Loss	1
Total	100
Distillation of Gasoline Distillate	
Gravity	53.3
IBP	130
10	193
20	227
30	256
40	275
50	297
60	316
70	336
80	356
90	384
95	405
EP	429
Recovery	98.5
Distillation of Diesel	
Gravity	29
IBP	450
EP	740
Flash	220
W & B S	0
Carbon	.02
Sulphur	.97

several ways, but mainly towards making a metallurgical coke. Upon analysis by several concerns this coke was found to meet metallurgical specifications with the exception of a trifle too much sulphur. Since then I have been able to eliminate the sulphur.

In the second cycle, I found that to vaporize the oil made it more susceptible to a chemical change, taking it then to a catalytic chamber where the vapors could be regulated to perform certain specific changes, which, to a certain degree, may be preducted by thermodynamics.

The choice of a catalyst, of which there are many, depends upon the line of endeavor one is pursuing. One catalyst will produce hydrogenation, one dehydrogenation, and another will act on the various complex compounds caused by the numerous intermediary reactions. Some authorities contend that the catalyst combines with the oil during the reaction, but I believe that it merely acts as a carrier or an affinity between complex compounds to form new compounds while still retaining its individuality. The catalysts I have used are a liquid and powdered chemical which pass through the system, and the cost of this type of catalyst is so low that it need not be reclaimed.

After many tests, using various catalysts, temperatures and pressures, I adopted a certain design, temperature and catalyst which resulted in exceedingly uniform results, especially when using the same type of residuum. In making these tests, I used residuum from Signal Hill, Wilmington, Huntington Beach, Venice, Midway, Elwood and Santa Fe Springs oil fields of California. The hardest to convert was a blend of Elwood and Santa Fe Springs, which is a very waxy stock.

An average test run of Signal Hill topped crude is shown in an accompanying tabulation.

Coking the 13 percent fuel produces 70 pounds of coke per barrel throughput.

The 3 percent wet gas was equivalent to 1150 cubic feet per barrel or 4 gallons per M. of natural gasoline. No analysis was made of dry gas.

Catalysts which I have used varied in cost from $18.00 to $36.00 per ton, and the amount used was approximately one half pound per barrel of throughput.

I have no special notes on treating, with one exception, and that is on a short experiment which was highly satisfactory, of submitting the distillate to ultra-violet light, and then filtering through bentonite clay.

My further experiments will be towards developing the process to that point where all operations will be conducted at atmospheric pressure and to attain a flexibility so that products may be varied by merely changing the combination of catalyst.

Dewaxing Plant Out of Junk

WITHIN the radius of a thousand miles or more, E. M. Dons and his assistants searched junk piles, machine shops, etc., for used steel and iron, to be used in constructing a modern dewaxing plant.

In order to save new material, the iron or steel must be second-hand, although in good shape. It was a gala day when a new junk pile was found by Dons or one of his assistants. It was similar to a whaling crew locating their first whale of the season.

When the hunters were through pawing through that junk pile, nothing was passed up that could be used in the construction of the dewaxing plant. Their's was a job for the war effort, made doubly hard through the difficulty of finding the right material at a price that was not prohibitory.

Being an engineer of specialized talents, Dons has enabled Mid-Continent Petroleum Corporation to rush installation of new war equipment in the quickest time and without the use of new steel, or putting a drain on factories and fabricators.

This was a well laid plan conceived long before the attack on Pearl Harbor or the more acute shortage in steel.

Dons, who then was chief engineer of the refinery in West Tulsa, was given the job of organizing the department. He also has been named chairman for the refinery division of the industrial salvage section in Oklahoma for the War Production Board.

Under his direction a survey was made of every important salvage yard within a thousand miles of Tulsa, including iron piles in Missouri, Illinois, Texas, Louisiana, Arkansas, Oklahoma, Kansas and Indiana.

Any tip on a promising junk pile was located by one of the eight engineers and followed up by a personal inspection. These engineers kept in touch with Dons by telephone. The director would visualize the place the equipment would fit into a new still or compressor and authorize purchase.

The result of this program has speeded up completion dates by months, and particularly has eliminated the necessity of making demand upon the steel industry.

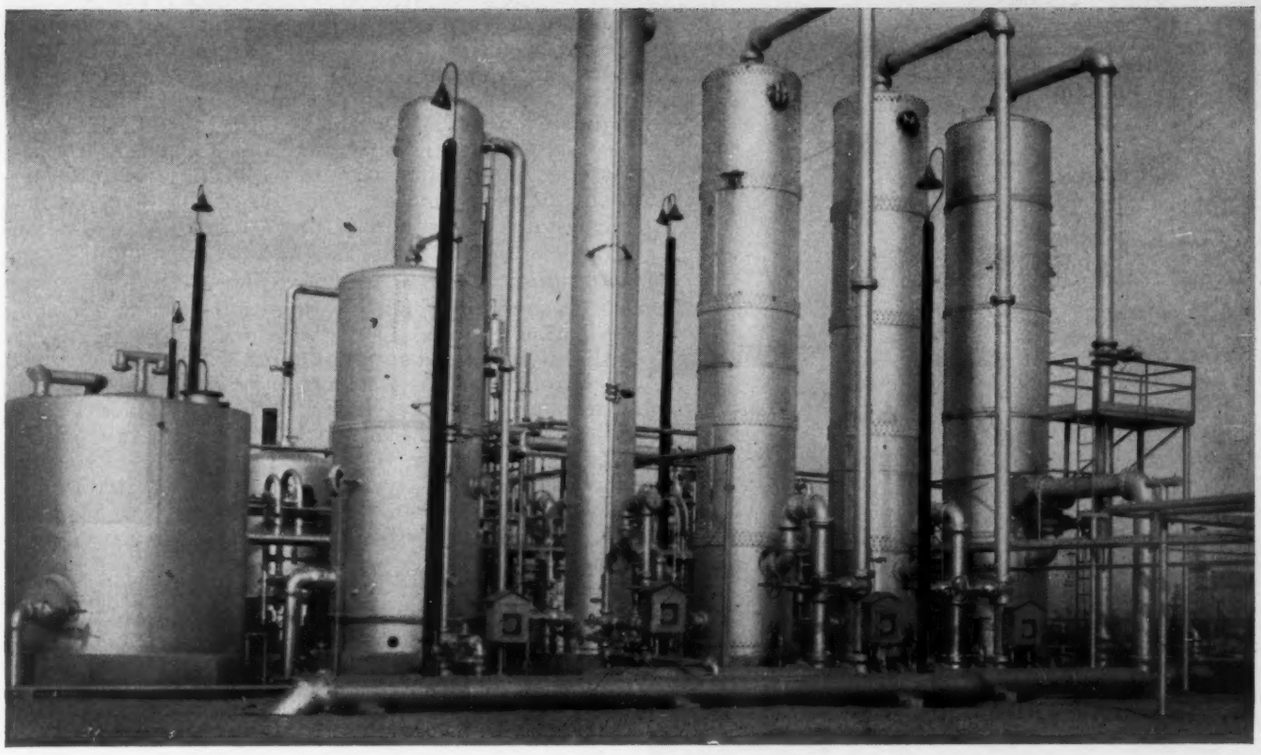
The salvage program was not forced by economical necessity for in many cases manufacture from reclaimed metals cost more than new equipment.

Refinery demands necessitate increasing utilities in the manufacturing department. This was solved by conversion of obsolete low-pressure compressors into high-pressure air units by purchase of second-hand high-pressure cylinders, revamping and installing on low-pressure compressors.

The engineers reclaimed 1,048,000 pounds of metal from old towers and stills which was revamped to make 31 reflux drums. Eleven towers were completed with trays and 11 service tanks were constructed from second-hand plate.

Protection against sabotage necessitated the building of fences, water lines and other equipment. In this program junk steel played a big part.

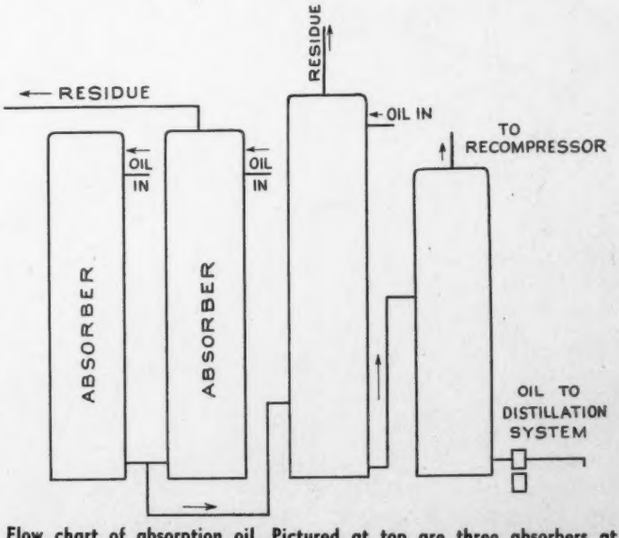
No junk of any nature is now discarded except small bits which is too small to be of any use. These pieces are shipped to steel mills in accordance with instructions of the War Production Board. But even these small pieces have added some 3,600,000 pounds of material to the nation's pile of metal.



Automatic Control of Absorption Oil Flow Improves Plant Recovery

OPERATING on a program which includes two-stage compression in one of its West Coast gasoline plants, General Petroleum Corporation effects recovery of the desired fractions by circulating a sufficient quantity of absorption oil at 150 pounds, gauge, to remove the propane and heavier components from the field gases. By absorbing all of the propane it is inevitable that some of the ethane will be dissolved in the absorption oil. To control this a combination tail absorber and fat-oil flash tower is stepped into the line of absorption-oil flow. Liquid-level controllers vent the fat oil from the high-pressure absorbers directly into the combination column which reduces the pressure on the oil from 150 to 50 pounds. This immediate drop in pressure releases the undesirable fractions along with some of the more desirable ones, which if not checked would flow into residue gas lines. Since the recovered vapors from the accumulator and storage tanks are gathered and compressed and piped to the combination column, a quantity of lean absorption oil is pumped over this tower so that none of the desirable fractions will escape. The lean oil enters the column above the absorbing trays while the fat oil from the high-pressure absorbers enters below the bubble plates. The oil flowing down in contact with the rising vapors merges with the fat oil and passes outward to the distillation system.

In combination with this system of pre-stabilization



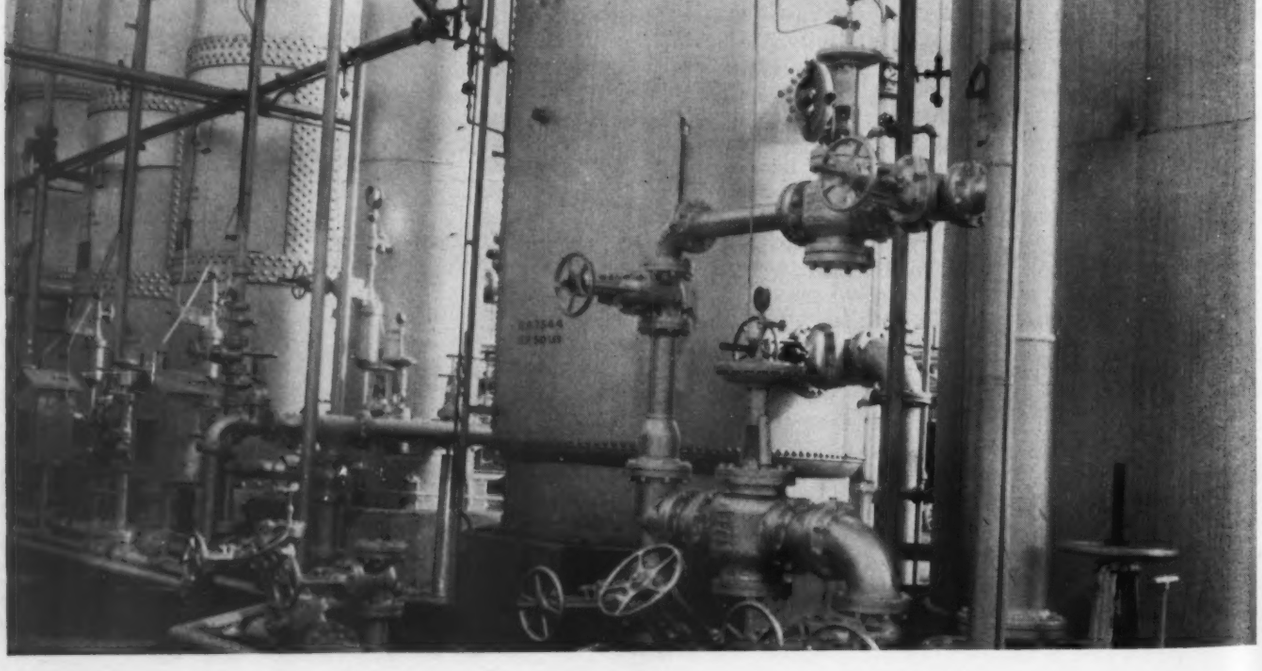
Flow chart of absorption oil. Pictured at top are three absorbers at the right. Next at the left is the prestabilization column, the surge tank and the intermediate supply tank.

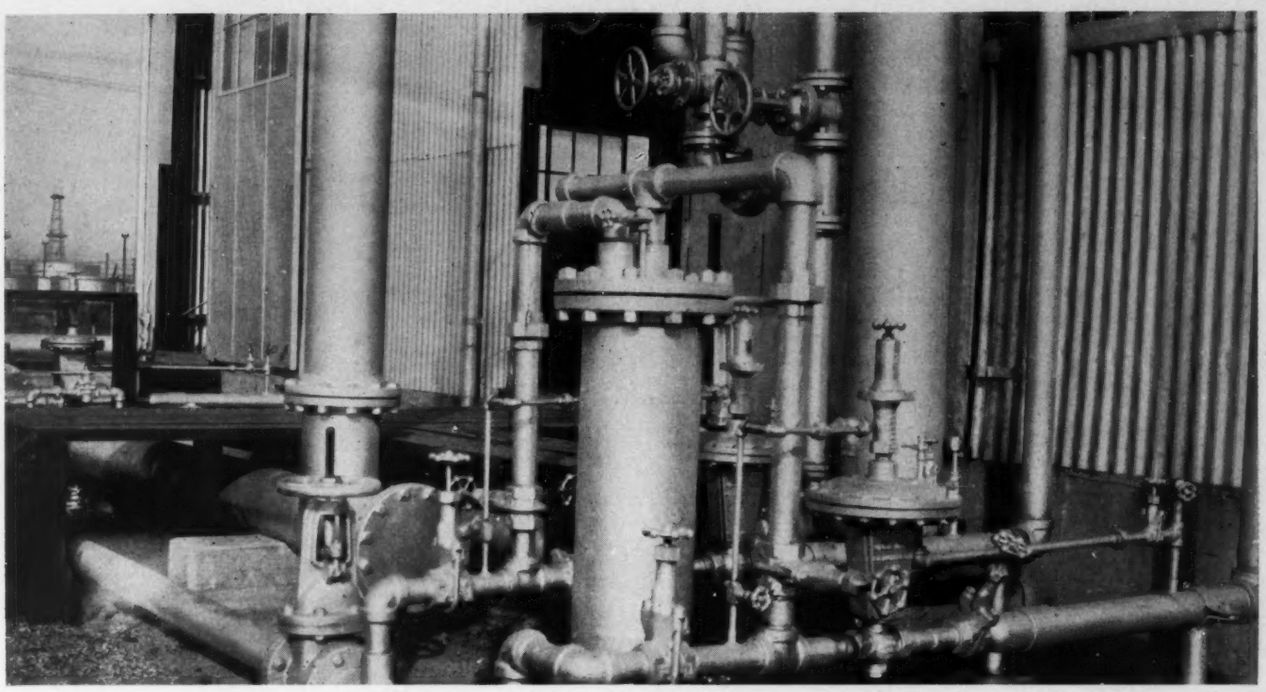
Liquid level instruments are responsible for automatic control of absorption oil. These are on the surge tank and control both high and low levels. Below: Diaphragm valves on the intermediate supply tank are controlled by liquid level instruments.

of the fat absorption oil, a surge tank is placed in the line of flow between the flash column and reabsorber, and the fat-oil pumps. Liquid-level controllers vent the oil from the base of the combination column to the surge tank which is equipped with both a high and a low liquid-level controlling installation, each working independently, but both hooked up to operate the diaphragm valve in the steam line to the fat-oil pump. When the operation of the plant is on a basis of constant flow of absorption oil, the level controllers float in their cases and the fat-oil pump runs at sufficient speed to remove the oil from the surge tank as rapidly as it is vented into it from the combination column. If the rate of flow changes only slightly from the normal rate, the high- and low-level controllers act to establish equilibrium by changing the speed of the fat-oil pump. If the rate is increased, the high-level controller opens the steam valve on the pump to increase the speed, and if the rate is decreased, the low-level instrument acts to reduce the speed of the pump. Both instruments are installed near the top of the surge tank and closely enough to each other to prevent wide variation in the rate of operation of the fat-oil pump. Should the action of the high-level instrument increase the speed of the fat oil unduly, the reverse action of the low-level instrument places a check against the excessive speed of the pump to establish equilibrium in the flow of absorption oil.

Since all absorption gasoline plants operate with a pre-determined quantity of oil in the system, any change in quantity immediately affects the efficiency of absorption or distillation by a deficiency or an unusual high level in some of the vessels and towers. To prevent this under-load and over-load liquid-level controllers are used. To work in coordination with these controllers an intermediate supply tank is set for the absorption oil that is maintained at a definite level by replenishing with fresh oil as required.

This tank is equipped with a float-operated target which indicates the quantity of oil in the vessel, and markings are painted on the gauge pole so that this





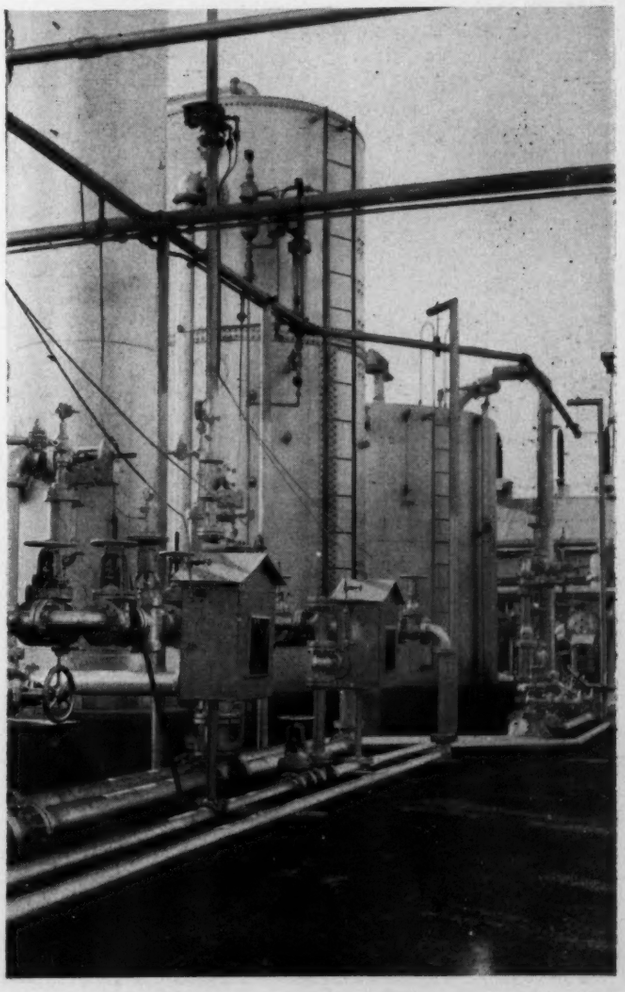
level will be maintained within a narrow range, but never shell full. The under-load instrument is located to control the quantity of the oil in the circulation system and opens a valve on the plant circulation suction line to permit a sufficient quantity of fresh oil to be drawn into the units until the working level is approached. The over-load instrument is located nearby and works to dump an excess of oil back into the intermediate supply tank until the level previously established has been reached.

In many plants, both fat- and lean-oil surge tanks frequently operate at such low pressures that pumps of increased capacity may be necessary, or perhaps more power is needed to maintain the required circulation of absorption oil through the columns and distillation equipment.

Since the flash tower in this plant and the instrument-controlled surge tank are both held at 50 pounds, the fat-oil pump takes suction at this pressure and consequently is enabled to work at a higher rate of efficiency than if it took suction at atmospheric or at a pressure only slightly above. At the same time, instead of venting the lean oil from the exchangers and coolers back into an atmospheric-pressure supply tank, this phase of the plant operation is held at or near distillation pressure, so that the lean-oil pump takes suction at a pressure that increases its efficiency also.

In addition to these controlling instruments on the quantity levels of the absorption oil, there is an alarm system which indicates by lights on the control board the location of any difficulty in the plant. In the circuit which controls these lights, are sirens which sound off so that the operator knows difficulties have arisen in the plant, and by glancing at the light panels can instantly determine where the trouble lies. Smoother operation is obtained with these instruments and the quality of the product remains uniform. By maintaining the proper quantity of oil in the system, the loss of valuable fractions in the residue gas is eliminated.

Conditioning and control of fuel to the engines is through scrubbers and regulators. Below: Continuous recording of specific gravity of residue gas is part of the control over plant efficiency.



Density of Liquefied Petroleum Gas Hydrocarbons

Their Mixtures and Three Natural Gasolines

B. R. CARNEY, Shell Oil Company, Inc.

IN THE use of loading density tables for liquefied petroleum gases it is necessary to convert volumes at actual loading temperatures to standard volumes at 60° F. or vice versa. Bulk transactions in these products are becoming increasingly common and for such deals reliable and generally acceptable volume-correction factors are desirable. The various standards in use do not agree well—particularly in the temperature range below 60° F. Also it was felt that the temperature range covered by these standards was somewhat too limited for all possible requirements.

Accordingly the original rather modest program of checking densities for the temperature range 0° to 60° F. was extended to a range of —50° to 140° F., and at the request of the API Committee on Measuring, Sampling and Testing Natural Gasoline some tests were made on typical natural gasolines of low, medium and high volatility. Also a few determinations were made on propylene and butene-1.

The direct results are orthobaric absolute densities for the individual hydrocarbons, two component mixtures, and the three natural gasolines. From these data can readily be computed the required temperature vs. volume factors using the density at 60° F. as a reference point.

The Hydrocarbons

The hydrocarbons were furnished by the Special Products Division of the Phillips Petroleum Company.

The paraffins were purified by batch fractionation through a column 6 inches in diameter and 25 feet high, packed with ½-inch metal lessing rings.

The propylene was obtained by fractionation of cracked vapors through a similar column. The butene-1 was made by dehydration of the appropriate alcohol, then purified by caustic washing and fractionating.

The propane, propylene, and butene-1 were tested for purity by fractionation in a low temperature distillation column and by Orsat-combustion analysis. The results indicated that the purity of all tested was 99.5 percent or better.

No tests for purity were made on the isobutane and normal butane, but it is known that the column used in their purification yields a product in which no impurities can be detected by low-temperature fractional analysis.

The two component blends used in this work were made by blending to approximately 50 mol percent each using the same pure hydrocarbons as used for the density determinations. Precise low-temperature fractional analyses were then run on the two blends with the following results.

THIS report was presented at the annual meeting of the Natural Gasoline Association of America, May 14 and 15, 1942, on behalf of the association's Technical Committee, which sponsored the investigation.

Part of the experimental work was done at the University of Tulsa under the direction of Professor W. L. Nelson. The project was completed in the laboratories of Phillips Petroleum Company under the direction of T. W. Legatski, chairman of the Liquefied Petroleum Gas subcommittee of the association. The volume and density correction tables were prepared by Dr. D. L. Katz and associates at the University of Michigan.

Blend 1	Mol. %	Liquid Volume % at 60° F.
Propane	52.6	48.27
Isobutane	47.4	51.73
Blend 2		
N-butane	52.4	48.91
N-pentane	47.6	51.09

The basic natural gasoline—73° API—was a product of 12-pound Reid vapor pressure from the Phillips plant at DeNoya, Oklahoma. A special blending stock of the following composition:

Propane	10% mol.
Iso-Butane	45% mol.
N-butane	45% mol.

was used to make the medium and high volatile blends for this base.

Thus the three natural gasolines had approximately the following compositions:

		Composition by Weight
73° API		100% 12 lb. base
89° API	26% blending stock	74% 12 lb. base
103° API	75% blending stock	25% 12 lb. base

The Experimental Apparatus

(a) *Metal Pycnometers*

The apparatus consisted of steel vessels of known volume for containing the hydrocarbon, and insulated bath for maintaining constant temperature, a centrifugal pump for stirring the bath liquid, a torsion balance and weights and a high-grade mercury thermometer.

Following are some details of the complete unit as used in the density determinations. The large cell, whose volume was accurately known, was used to contain the hydrocarbon; the small cell served merely

as a liquid expansion chamber. The cells were made of ASTM A-70 steel, chosen because it is the same or nearly the same as that used in the construction of tank cars. The cells were cadmium plated to prevent rusting. The valve connecting the two cells was an ordinary high-pressure stainless-steel needle valve. Its construction was such that when fully open the pressure was held by a metal-to-metal seat, thus relieving the strain on the packing and reducing the chance for leakage. The valve at the top of the unit was an ordinary brass-body steel needle valve. The assembly was tested for leaks with hydrogen at 600 pounds pressure. In practice two of these units were used simultaneously.

The insulated bath had a capacity of about 12 gallons. At temperatures above 32° F., water was used as the bath liquid; below 32° F. an anti-freeze mixture of ethylene glycol and water was used. The temperature was controlled by manual intermittent addition of ice at temperatures above 32° F. Below 32° F. dry ice was used.

The centrifugal pump circulated the bath liquid at the rate of about 4 gallons per minute.

The torsion balance was tested before use for accuracy, sensitivity, stability, equality of length of the balance arms, etc. It was tested during use for reproducibility of weights by weighing a piece of iron of about 20 pounds weight at different times during the day, and on successive days. These tests indicated that a weight could be reproduced in a range of ±0.0015 pound. The weights used were calibrated to an accuracy of ±0.0002 pound on a smaller and more sensitive balance.

(b) *Glass Pipette*

For the purpose of determining the volume of the metal pycnometer, water was used since it was the only practicable liquid which had been investigated thoroughly enough to provide density values of the necessary accuracy. The lowest temperature, therefore, at which a direct volume measurement could be made was 32° F. The determination of the volumes at temperatures below 32° F. was made by extrapolating the volume versus temperature curve. It was considered impracticable to carry the extrapolation to temperatures below zero degrees Fahrenheit. It was necessary, therefore, to devise a different method to measure densities below this temperature. It was for this purpose that the glass pipette was designed. It consisted of a glass bulb of approximately 50 ml capacity to which was attached a long slender stem suitably graduated and calibrated for volume.

(c) *Temperature Measurement*

All bath temperatures from 140 to —5° F. were measured by a U. S. Bureau of Standards Certified mercury thermometer. These temperatures were believed to be correct to ± 0.1° F.

The temperatures from —5 to —35° F. were measured by a mercury thermometer which had been calibrated against a U. S. Bureau of Standards mercury thermometer. These temperatures were considered correct to ± 0.15° F.

A 5-junction copper-constantan thermocouple was used to measure the bath temperature below —35° F. The thermocouple was calibrated against the Bureau of Standards thermometers at the same time that the mercury thermometer was being calibrated. Due to operating difficulties, the temperatures measured by the thermocouple are somewhat more inaccurate.

TABLE 1

Correction for the Compressibility of Water

Temp. ° F.	Internal Pressure 200 Lb./Sq. In.	Internal Pressure 450 Lb./Sq. In.
	Volume Correction to be Subtracted ml.	
68	3.04	6.85
60	3.07	6.90
39.2	3.15	7.10

These temperatures (—35 to —50° F.) are believed correct to ± 0.25° F. This temperature uncertainty represents a possible error of ± 0.00015 in the experimental densities. In the final correlation of the data, however, it is believed that the uncertainty in density values is reduced to a value commensurate with that of the other measurements.

The Experimental Procedure

(a) *Calibration of Metal Pycnometers*

Due to the fact that there are several effects entering into the water-weight capacity of the cells the derivation of the true volume of the cells is somewhat involved. Because the absolute accuracy of the density values depends directly on the values taken for the volume of the cells, it was decided to present in detail the method used for arriving at these volumes.

The calibration was made by finding the water-weight capacity at various temperatures between 0 and 140° F. and at internal pressures of 0, 200 and 450 psi. gauge. To the water-weight capacities at the different conditions under which they were found, several corrections were applied to arrive at the true volume.

To find the water-weight capacity the cell was first pumped down with a mechanical vacuum pump to a pressure of about 1 mm. Hg. As much distilled water was drawn into the cell as it would take. The water was then pumped on for several minutes to remove the last traces of dissolved gases and the cell then filled liquid full. A 10-inch length of ¼-inch pipe was then attached to the valve and filled to overflowing with distilled water. The water in the pipe acted as a reservoir to keep the cell filled when placed in the constant-temperature bath. The cell was kept in the bath for at least 1 hour. The temperature was not allowed to vary during this time by more than ± 0.1° F. from the desired temperature. After a period of 1 hour, observations of the water level at the top of the pipe were made. If no change in level could be observed in 10 minutes the cell and contents were considered to be at the bath temperature. At this point, if the capacity at a pressure above atmospheric was desired, hydrogen gas pressure was applied to the top of the water in the pipe through a tee connection and measured by a gauge in the tee. When the desired pressure was reached, the valve on the cell was closed. In either case the pipe was removed

TABLE 2

Change in Volume of Density Cells From the Volume at 60° F.

Temp. ° F.	ΔV ml.
60	0.0
39.2	1.7
20	3.3
0	4.9

after closing the valve, the cell dried carefully and weighed.

The weight of the water contained was found by taking the difference between the full weight and the tare weight. The volume (in ml.) was calculated by multiplying the pounds water weight by 453.59 and dividing by the density of water.[12] When external pressure was applied, correction had to be made for the compressibility of the water. To do this Amagat's[12] value for the compressibility of water was used as follows:

$$\text{Compressibility factor} \times \text{approx. vol.} \times \frac{\text{gage pressure}}{14.7} = \text{volume correction.}$$

Typical results of these calculations are listed in Table 1.

Another correction that had to be made was that due to the water hold-up in the valve. The construction of the valve was such that some water was held inside the valve on the low-pressure side. In calibrating it was impossible to be certain that all this water had been removed. Consequently, this water was left in the valve during calibration and its volume subsequently determined to be 0.6 cc. This amount was subtracted from the calibration.

Because the change in volume with temperature was small, and due to the lack of a means of calibrating below 32° F., the change in volume with temperature was calculated using the formula for the cubical expansion of a solid.

$$\Delta V = 3Vk\Delta t$$

Where:

V = volume of the cell
k = linear coefficient of expansion — 6.0×10^{-6}, (13)
Δt = temperature change in °F.
ΔV = volume change

Calculated changes in volume from that at 60° F. are given in Table 2.

As shown in Table 2, the change in volume is so small that the method of calibration would not be accurate enough to extrapolate experimental values for the volume at 60 and 39.2° F. to the lower temperatures.

Calibration of the cells at internal pressures of 200 and 450 pounds pressure indicated that the cells stretched about 0.8 ml for a pressure increase of 100 pounds per square inch.

By using the known vapor pressures of the hydrocarbons studied, Table 3 was constructed to show the volume added to allow for the stretch of the cell under the vapor pressure of the hydrocarbon it contained.

After applying the foregoing corrections to the water-weight capacities as directly measured, the volumes used for computing the densities were found. In the more extended program the same procedure was followed for the wider temperature ranges. Complete results are shown in Table 4.

As a final check on the calibrations of the two pycnometers normal butane was run simultaneously in both at various temperatures with the following results:

Densities in Grams per ml.

	60.0° F.	39.2° F.	20° F.	0° F.
1	0.5839	0.5964	0.6082	0.6196
2	0.5840	0.5963	0.6081	0.6198

(b) *Calibration of Glass Pipette*

Since the pipettes were calibrated for room temperature (about 70° F.), a correction was applied for the change in the pipette volume with the reduction in temperature. A linear coefficient of expansion of 0.034×10^{-4} per °C. was used. The calibration was assumed to be correct at 70° F. A typical calculation for the volume correction is as follows:

$$\Delta V = 3kV \frac{(70 - t_1)}{1.8}$$

where

$k = 0.034 \times 10^{-4}$
V = pipette volume = 54 ml.
t_1 = temperature of pipette = —20° F.

$$\Delta V = 3 \times 0.034 \times 10^{-4} \times \frac{54\ (70 + 20)}{1.8} = 0.027 \text{ ml.}$$

The correction is subtracted from the observed volume.

A calculation based on Raoult's law showed that no correction was needed in the liquid volume for changes in the vapor space in the stem of the pipette due to varying the temperature of the contents.

TABLE 3

Stretch in the Cells Due to Vapor Pressure

Temp. ° F.	Stretch Correction ml.	
	C_3 Hydrocarbons	C_4 Hydrocarbons
60	0.7	0.2
39.2	0.5	0.1
20	0.3	0.0
0	0.2	0.0

Determination of Densities of the Hydrocarbons

After completion of the calibration of the large cell, the small cell was attached and the unit was then pumped down to a pressure of 1 mm. Hg. or less. The hydrocarbon was then flashed into the unit through the valve on the small cell until the large cell was liquid full and the small cell about one third full. The unit was placed in the constant-temperature bath with the small valve closed and the large valve open where it remained for at least 1¼ hours. The liquid level in the bath was adjusted so that the large valve was about one half submerged. By so doing, the small cell was kept at a temperature slightly above that of the bath. At bath temperatures above 60° F. heat was applied to the small cell with an electric heater to effect this purpose. This caused the vapor pressure in the small cell to exceed the vapor pressure of the hydrocarbon in the large cell thus eliminating the possibility of bubbles.

The temperature was not allowed to vary more

TABLE 4

Corrected Volumes of the Metal Pycnometers in ml.

A. Preliminary Test Program.

° F.	Unit 1		Unit 2	
	C_3	C_4	C_3	C_4
60	4554.3	4553.6	4564.4	4563.9
39.2	4553.1	4552.9	4562.5	4562.1
20	4550.6	4550.6	4560.7	4560.4
0	4548.9	4548.7	4559.0	4558.8

B. Extended Test Program.

° F.	Unit 1			Unit 2		
	C_3	C_4	C_5 and Nat. Gaso.	C_3	C_4	C_5 and Nat. Gaso.
140	4573.9	4572.6	4571.9	4572.4	4571.1	4570.4
120	4572.0	4570.7	4570.2	4570.8	4569.3	4568.8
100	4569.9	4568.8	4568.5	4568.6	4567.5	4567.2
80	4567.9	4567.1	4566.9	4566.6	4565.8	4565.6
60	4565.9*	4565.4	4565.2	4564.6	4564.1	4563.9
40	4564.1	4563.7	4563.6	4562.7	4562.3	4562.2
20	4562.2	4561.9	4561.9	4560.8	4560.5	4560.5
0	4560.5	4560.3	4560.3	4558.9	4558.7	4558.7

* Between the two test programs this unit was inadvertently subjected to a hydrostatic pressure causing a slight bulge which was evident when the second set of tests were started. This explains the difference between the two calibrations.

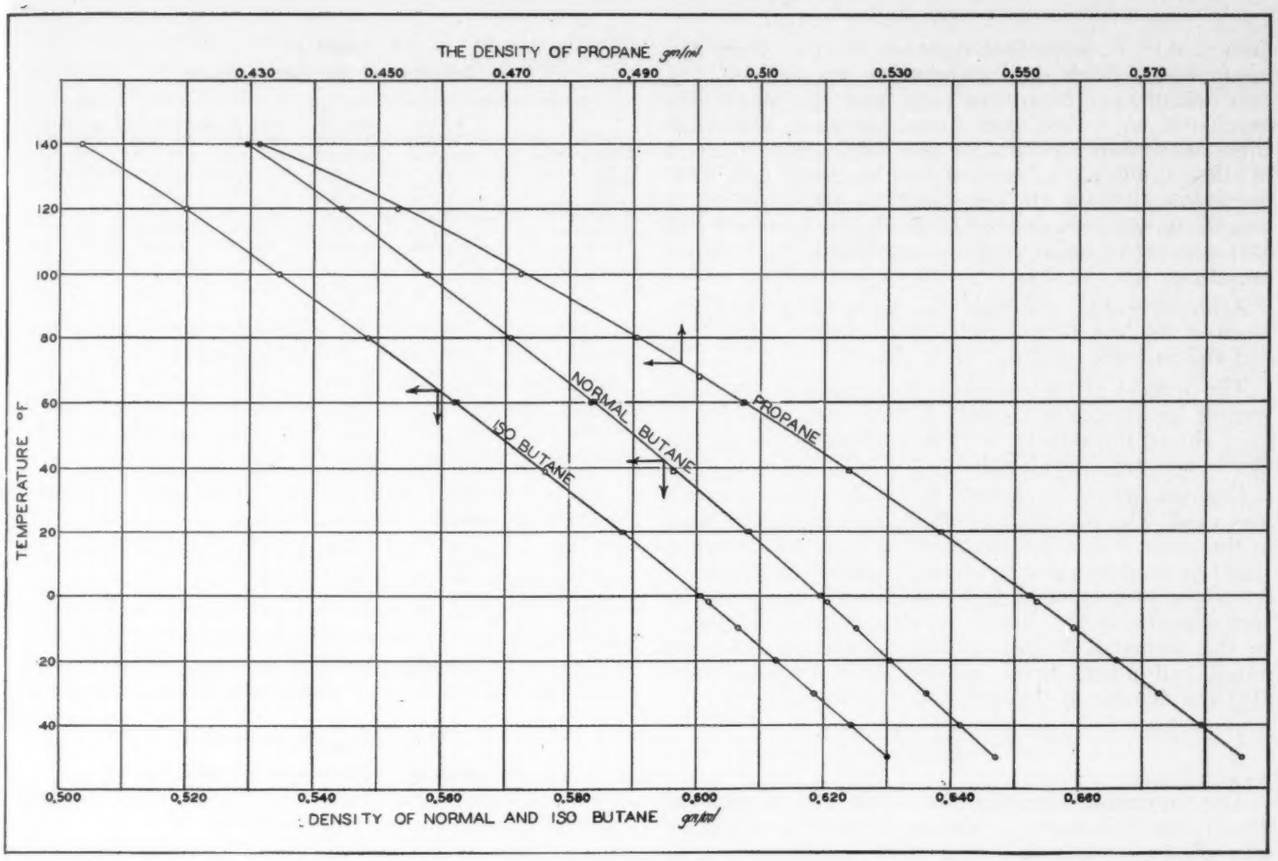


FIGURE 1

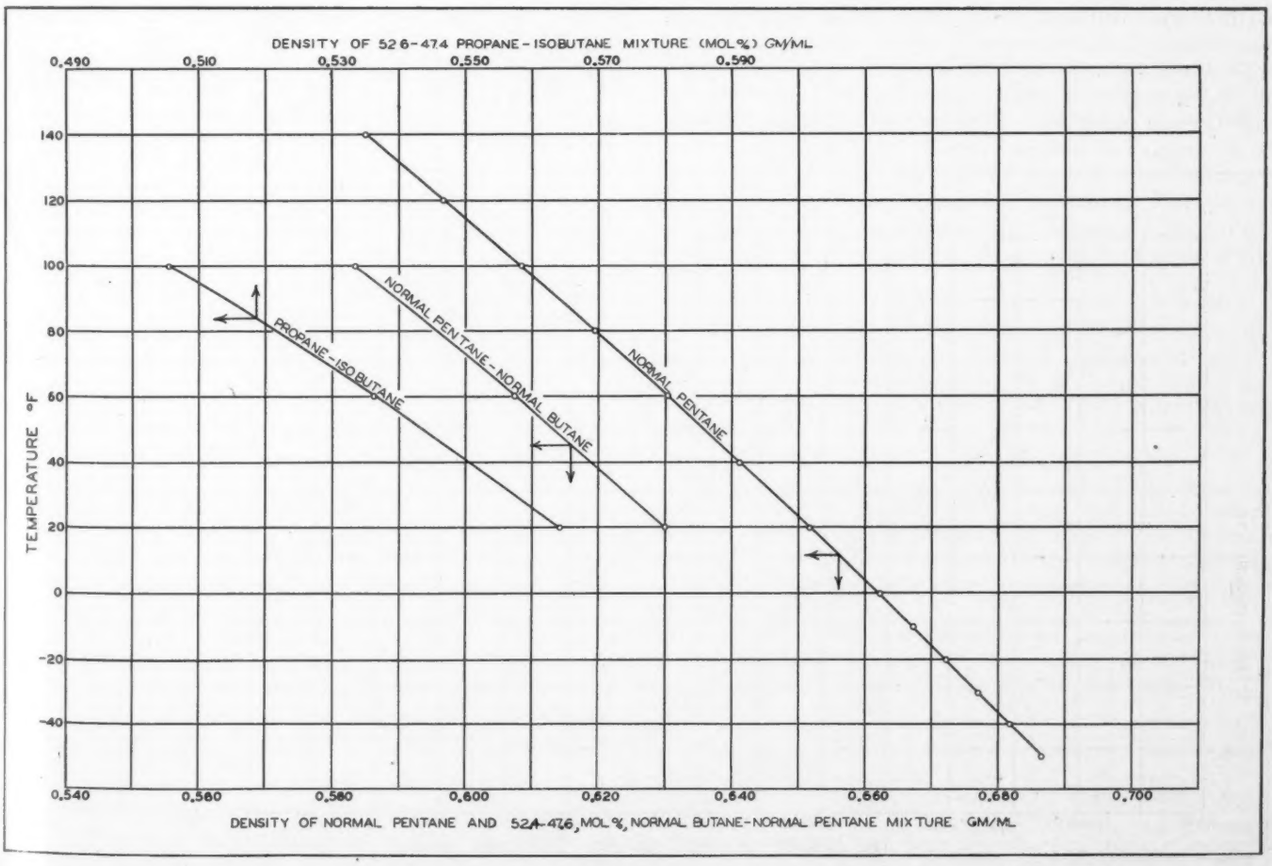


FIGURE 2

than ± 0.1° F. from that desired. After at least 1¼ hours in the bath, the large valve was closed, the unit withdrawn from the bath and the small cell pumped down to less than 1 mm. pressure. The small valve was then closed and the large valve opened to allow the liquid to expand into the small cell. This operation allowed all weighings to be made at or near room temperature without loss of material and without risk of deforming the cell due to high liquid pressure.

After weighing, the unit was replaced in the bath, more of the hydrocarbon charged into the small cell, and the process repeated for a check.

The weight of hydrocarbon was equal to the total weight less the tare weight. The density was found by dividing the weight of hydrocarbon by the appropriate volume, from Table 4.

For temperatures below 0° F. the glass pipette was used. The pipette was filled to a convenient level in the stem with a hydrocarbon so that the meniscus could be read at a temperature "t" at which the density of the hydrocarbon was available. Any change in temperature of the liquid would produce a change in the meniscus height. If the volume at "t" were noted and noted again at some other temperature "t'," the density of the liquid at "t'" would be

$$D_{t'} = D_t \frac{\text{Vol. at t}}{\text{Vol. at t'}}$$

The procedure used for this work was to use the density at 0° F. as the reference density. The pipette was filled as nearly full as possible and immersed in the constant temperature bath at 0° F. The total volume of liquid at this temperature was noted. The bath temperature was then reduced by intervals not exceeding 15° F. and usually 10° F. At each level, the bath temperature was held constant to ± 0.1° F. and until the meniscus showed no change in position for a period of 4 minutes. It was found that 15 minutes at a constant temperature was sufficient to bring the pipette and contents to the bath temperature. These experimentally determined volumes were plotted against temperature and "smoothed" values taken from the curve at the desired temperatures for calculating the density.

TABLE 5
Densities of the Hydrocarbons

Hydrocarbon	0.0° F. Density gm./ml.	20.0° F. Density gm./ml.	39.2° F. Density gm./ml.	60.0° F. Density gm./ml.	68.0° F. Density gm./ml.
Propane	0.5522	0.5384	0.5240	0.5073	0.5004
Isobutane	0.6008	0.5886	0.5762	0.5626	.....
N-butane	0.6197	0.6082	0.5963	0.5840	.....
Propylene	0.5710	0.5553	0.5396	0.5215	.....
Butene-1	0.6896	0.6260	0.6135	0.6000	.....

Table 5 shows the results of the first group of tests covering the range 0-60° F.

Table 6 shows the results of the more extended test program for the range 0-140° F.

The densities at temperatures below 0° F. were found by plotting the observed volumes of a hydrocarbon against temperature. The volumes were read from the curves at 2° F. intervals. From these vol-

TABLE 6
Densities of Hydrocarbons and Mixtures

HYDROCARBON	TEMPERATURE ° F. 0	20	40	60	80	100	120	140
Propane	.....	.....	.....	0.5073	0.4906	0.4722	0.4530	0.4314
Isobutane	.....	.....	.....	0.5620	0.5486	0.5345	0.5199	0.5035
N-butane	.....	.....	.....	0.5833	0.5709	0.5578	0.5442	0.5294
N-pentane	0.6621	0.6518	0.6411	0.6304	0.6194	0.6083	0.5968	0.5849
Propane-Isobutane	.....	0.5641	.....	0.5362	.....	0.5052	.....	.....
N-butane–N-pentane	.....	0.6300	.....	0.6073	.....	0.5833	.....	.....
73° API Nat-Gaso	0.7187	0.7084	0.6990	0.6896	0.6793	0.6692	0.6590	0.6485
89° API Nat-Gaso	0.6730	0.6627	0.6517	0.6403	0.6292	0.6181	0.6065	0.5949
103° API Nat-Gaso	0.6392	0.6282	0.6163	0.6048	0.5926	0.5810	0.5690	0.5573

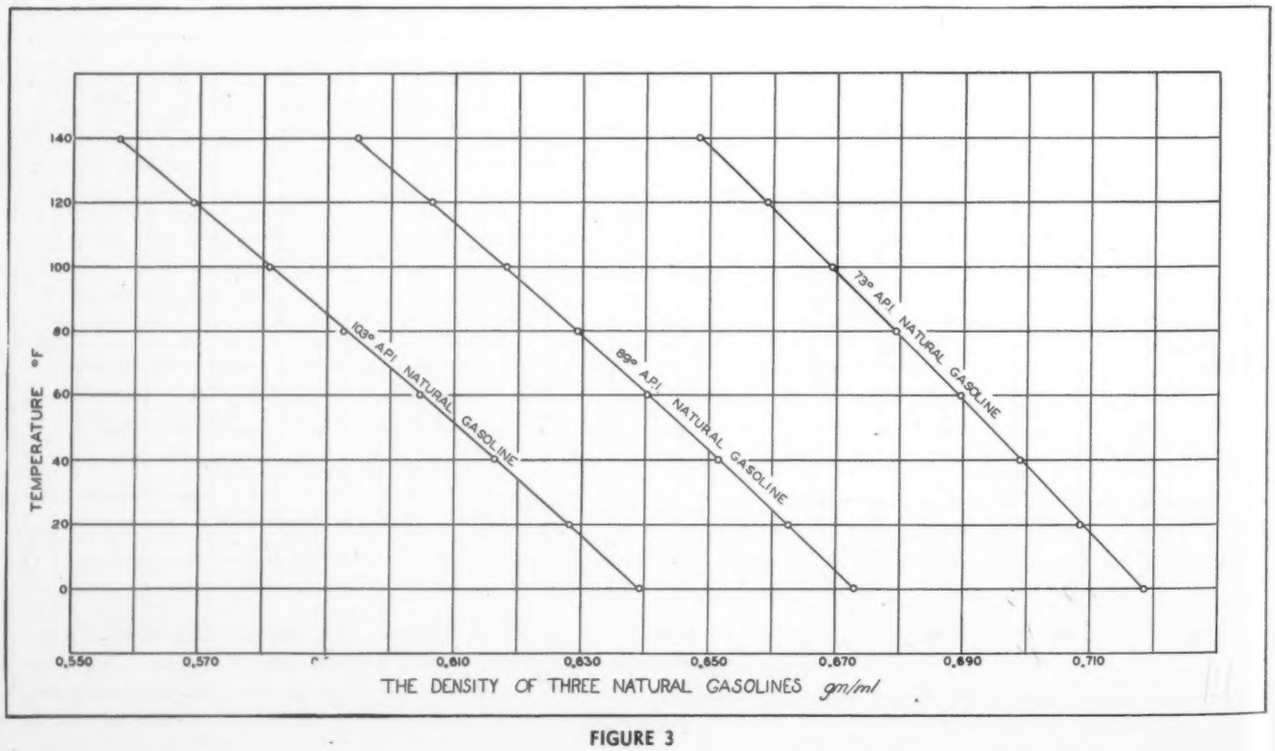


FIGURE 3

umes the density was calculated as previously explained. These densities are listed in Table 7.

TABLE 7
The Density of Several Hydrocarbons (Low Temperature Range) gm/ml.

° F.	Propane	Isobutane	Normal Butane	Normal Pentane
—50	0.5858	0.6301	0.6470	0.6866
—48	.5845	.6290	.6459	.6857
—46	.5832	.6278	.6448	.6847
—44	.5820	.6267	.6438	.6838
—42	.5807	.6255	.6427	.6828
—40	.5794	.6244	.6416	.6818
—38	.5781	.6232	.6404	.6808
—36	.5767	.6221	.6393	.6799
—34	.5754	.6209	.6382	.6789
—32	.5741	.6198	.6371	.6780
—30	.5728	.6186	.6361	.6770
—28	.5714	.6174	.6350	.6760
—26	.5701	.6162	.6339	.6750
—24	.5687	.6150	.6328	.6740
—22	.5674	.6138	.6317	.6730
—20	.5660	.6127	.6306	.6721
—18	.5646	.6115	.6295	.6711
—16	.5633	.6103	.6284	.6701
—14	.5619	.6091	.6273	.6691
—12	.5605	.6079	.6262	.6681
—10	.5592	.6067	.6251	.6671
— 8	.5578	.6055	.6240	.6661
— 6	.5564	.6044	.6229	.6651
— 4	.5550	.6032	.6218	.6641
— 2	.5536	.6020	.6207	.6631

All data except for the two olefines, are shown graphically in Figures 1, 2 and 3.

Discussion of Density Data

Consideration of the probable errors in the method and apparatus indicates that the densities are accurate to ± 0.00015. The experience gained in using the method and apparatus for many different hydrocarbons, with several different operators has shown that density values can be easily reproduced to ± 0.0002. After plotting the data and drawing a smooth curve through the points the density values thus obtained from the curve are believed accurate to ± 0.00015.

The work of Dana et al[1] remains up to this writing the most complete set of density determinations found in the literature. The data presented herein were compared with the values by Dana. These two sets of values for propane, isobutane, and normal butane are given in Table 8. Values from other sources are compared in Table 9.

The following is a short discussion, for each of the pure hydrocarbons investigated, of a comparison of the new data presented in this report with the data found in the literature.

Propane

The correlation with the data of Dana[1] in Table 8 has an average difference of 0.0008 ± 0.0002 if the values at 70 to 110° F. are omitted. If the impurity is assumed to be isobutane and the new densities are taken as correct, the propane used by Dana would be 98.5 percent pure. The claim of its purity is 99 percent. It is noteworthy that the difference in density values is greatest at the higher temperatures and decreases as the temperature is lowered. This trend is in the direction to be expected if the propane was contaminated by some heavier hydrocarbon. The lack of agreement with the two values by Egloff[3] and Maass[2] (See Table 9) is probably due to their use of impure hydrocarbons.

The data of Van der Vet[10] agree in general very well with the data reported herein, the deviation being + 0.0002. The deviation is somewhat larger at temperatures above 105° F. where Van der Vet's data appear to be somewhat erratic.

Isobutane

Densities for isobutane have been reported by Dana[1] and Coffin[4] for considerable ranges of temperature.

As seen in Table 8 the difference between the densities by Dana and the new densities is 0.0012 ± 0.0002. Dana claims a purity, "approximately 97 percent," for the isobutane used. Assuming the impurity to be normal butane and the data reported herein as correct, the purity would be 94 percent.

On the same basis the data of Coffin[4] are based on isobutane of only 90-percent purity. The purity is so low, in fact, that the values of the rate of change of the density with temperature are between isobutane and normal butane.

The data of Van der Vet[10] show somewhat greater densities than those of this work, the deviation being + 0.0005 with some erratic data above 105° F. The deviation points to an impurity, probably normal butane in the isobutane.

Normal Butane

Beside the data of Dana[1] and Van der Vet[10] two values, one each by Huckel[5] and by Coffin[4], were available. It appeared that some error entered into the densities by Dana at temperatures below 40° F. The density by Coffin[4] agrees within the experimental error of this work. The density by Huckel[5] differs from this work by an amount slightly less than the experimental error.

The data of Van der Vet[10] show densities lower by about 0.0008 with some erratic data at both extremes of the temperature range investigated.

Normal Pentane

The correlation of this work with the collection of unrelated density values by Chavanne,[6] Seitz,[7] Dornte[8] and Brown[9] (Table 9) show good agreement. Only the density at 14° F. differs from this work to an extent greater than the experimental error. Because of the low volatility of pentane, at the temperatures reported, the measurement of its density can be made with extreme accuracy provided the hydrocarbon can be obtained sufficiently pure. The excellent agreement between this work and that of the four different investigators gives some proof of the accuracy of the method employed here.

Olefins

Coffin and Maass[4] have published density data on propylene, and Maass and Wright[2] give densities for butene-1. Both publications cover the same temperature range as covered in this work. The results agree quite closely.

The Mixtures

These were tested primarily to determine the deviation if any of the densities—and derived volume factors—from those calculated by use of the perfect solution laws. A comparison of the calculated and observed densities for the temperatures actually checked is as follows:

BLEND 1			At 20° F.	60° F.	100° F.
Propane	48.27%*	Observed	.5641	.5362	.5052
Isobutane	51.73%	Calculated	.5646	.5359	.5041
		Difference	—.0005	.0003	.0011
BLEND 2					
N-butane	48.91%*	Observed	.6300	.6073	.5833
N-pentane	51.09%	Calculated	.6304	.6076	.5836
		Difference	—.0004	—.0003	—.0003

* Liquid volume percent at 60° F.

N.G.A.A. Liquefied Petroleum Gas Volume Correction Factors (1942)

Degrees Fahrenheit	SPECIFIC GRAVITY AT 60° F./60° F.																								
	0.500	Propane 0.5079	0.510	0.520	0.530	0.540	0.550	0.560	iso-Butane 0.5631	0.570	0.580	n-Butane 0.5844	0.590	0.600	0.610	0.620	iso-Pentane 0.6246	0.630	n-Pentane 0.6310	0.640	0.650	0.660	0.670	0.680	0.690	0.700
—50	1.160	1.155	1.153	1.146	1.140	1.133	1.127	1.122	1.120	1.116	1.111	1.108	1.106	1.102												
—45	1.153	1.148	1.146	1.140	1.134	1.127	1.120	1.117	1.115	1.111	1.106	1.103	1.101	1.097												
—40	1.147	1.142	1.140	1.134	1.128	1.122	1.117	1.111	1.110	1.106	1.101	1.099	1.097	1.093												
—35	1.140	1.135	1.134	1.128	1.122	1.116	1.111	1.106	1.105	1.101	1.096	1.094	1.092	1.088												
—30	1.134	1.129	1.128	1.122	1.116	1.111	1.106	1.101	1.100	1.096	1.092	1.090	1.088	1.084												
—25	1.127	1.122	1.121	1.115	1.110	1.105	1.100	1.095	1.095	1.091	1.087	1.085	1.083	1.080												
—20	1.120	1.115	1.114	1.109	1.104	1.099	1.095	1.090	1.089	1.086	1.082	1.080	1.079	1.076												
—15	1.112	1.109	1.107	1.102	1.097	1.093	1.089	1.084	1.082	1.080	1.077	1.075	1.074	1.071												
—10	1.104	1.102	1.100	1.095	1.091	1.087	1.083	1.079	1.078	1.075	1.072	1.071	1.069	1.066												
— 5	1.098	1.096	1.094	1.089	1.085	1.081	1.077	1.074	1.073	1.070	1.067	1.066	1.065	1.061												
0	1.092	1.088	1.088	1.084	1.080	1.076	1.072	1.069	1.068	1.066	1.063	1.062	1.061	1.058	1.055	1.053	1.052	1.051	1.051	1.050	1.048	1.046	1.045	1.044	1.043	1.042
2	1.089	1.085	1.085	1.081	1.077	1.074	1.070	1.067	1.066	1.064	1.061	1.060	1.059	1.056	1.053	1.051	1.050	1.049	1.049	1.048	1.046	1.045	1.044	1.043	1.042	1.041
4	1.086	1.083	1.082	1.079	1.075	1.071	1.068	1.065	1.064	1.062	1.059	1.058	1.057	1.054	1.051	1.049	1.049	1.048	1.048	1.047	1.045	1.043	1.042	1.041	1.041	1.039
6	1.084	1.080	1.080	1.076	1.072	1.069	1.065	1.062	1.061	1.059	1.057	1.055	1.054	1.052	1.050	1.048	1.047	1.046	1.046	1.045	1.043	1.042	1.041	1.040	1.039	1.038
8	1.081	1.078	1.077	1.074	1.070	1.066	1.063	1.060	1.059	1.057	1.055	1.053	1.052	1.050	1.048	1.046	1.046	1.045	1.045	1.044	1.042	1.040	1.039	1.038	1.037	1.036
10	1.078	1.075	1.074	1.071	1.067	1.064	1.061	1.058	1.057	1.055	1.053	1.051	1.050	1.048	1.046	1.044	1.044	1.043	1.043	1.042	1.040	1.039	1.038	1.037	1.036	1.035
12	1.075	1.072	1.071	1.068	1.064	1.061	1.059	1.055	1.055	1.053	1.051	1.049	1.048	1.046	1.044	1.042	1.042	1.041	1.041	1.039	1.038	1.037	1.036	1.035	1.035	1.034
14	1.072	1.070	1.069	1.066	1.062	1.059	1.056	1.053	1.053	1.051	1.049	1.047	1.046	1.044	1.042	1.041	1.040	1.039	1.039	1.038	1.037	1.036	1.035	1.034	1.033	1.032
16	1.070	1.067	1.065	1.063	1.059	1.056	1.054	1.051	1.050	1.048	1.046	1.045	1.044	1.043	1.041	1.039	1.039	1.038	1.038	1.036	1.035	1.034	1.033	1.032	1.032	1.031
18	1.067	1.065	1.064	1.061	1.057	1.054	1.051	1.048	1.048	1.046	1.044	1.043	1.042	1.041	1.039	1.038	1.037	1.036	1.036	1.035	1.034	1.033	1.032	1.031	1.030	1.029
20	1.064	1.062	1.061	1.058	1.054	1.051	1.049	1.046	1.046	1.044	1.042	1.041	1.040	1.039	1.037	1.036	1.035	1.034	1.034	1.033	1.032	1.031	1.030	1.029	1.029	1.028
22	1.061	1.059	1.058	1.055	1.051	1.049	1.047	1.044	1.044	1.042	1.040	1.049	1.038	1.036	1.035	1.034	1.033	1.032	1.032	1.031	1.030	1.030	1.029	1.028	1.028	1.027
24	1.058	1.056	1.055	1.052	1.049	1.046	1.044	1.042	1.042	1.040	1.038	1.037	1.036	1.034	1.033	1.032	1.032	1.031	1.031	1.030	1.029	1.028	1.027	1.026	1.026	1.025
26	1.055	1.053	1.052	1.050	1.046	1.044	1.042	1.039	1.039	1.037	1.036	1.036	1.034	1.033	1.032	1.031	1.030	1.029	1.029	1.028	1.027	1.027	1.026	1.025	1.025	1.024
28	1.052	1.050	1.049	1.047	1.044	1.041	1.039	1.037	1.037	1.035	1.034	1.034	1.032	1.031	1.030	1.029	1.029	1.028	1.028	1.027	1.026	1.025	1.024	1.023	1.023	1.022
30	1.049	1.047	1.046	1.044	1.041	1.039	1.037	1.035	1.035	1.033	1.032	1.032	1.030	1.029	1.028	1.027	1.027	1.026	1.026	1.025	1.024	1.024	1.023	1.022	1.022	1.021
32	1.046	1.044	1.043	1.041	1.038	1.036	1.035	1.033	1.033	1.031	1.030	1.030	1.028	1.027	1.026	1.025	1.025	1.024	1.024	1.023	1.022	1.022	1.021	1.021	1.020	1.020
34	1.043	1.041	1.040	1.038	1.036	1.034	1.032	1.031	1.030	1.029	1.028	1.028	1.026	1.025	1.024	1.023	1.023	1.022	1.022	1.022	1.021	1.021	1.020	1.019	1.019	1.018
36	1.039	1.038	1.037	1.035	1.033	1.031	1.030	1.028	1.028	1.027	1.025	1.025	1.024	1.023	1.023	1.022	1.022	1.021	1.021	1.020	1.019	1.019	1.018	1.018	1.017	1.017
38	1.036	1.035	1.034	1.032	1.031	1.029	1.027	1.026	1.025	1.025	1.023	1.023	1.022	1.021	1.021	1.020	1.020	1.019	1.019	1.019	1.018	1.018	1.017	1.016	1.016	1.015
40	1.033	1.032	1.031	1.029	1.028	1.026	1.025	1.024	1.023	1.023	1.021	1.021	1.020	1.019	1.019	1.018	1.018	1.017	1.017	1.017	1.016	1.016	1.015	1.015	1.014	1.014
42	1.030	1.029	1.028	1.026	1.025	1.023	1.023	1.022	1.021	1.021	1.019	1.019	1.018	1.017	1.017	1.016	1.016	1.015	1.015	1.015	1.014	1.014	1.013	1.013	1.013	1.013
44	1.027	1.026	1.025	1.023	1.022	1.021	1.020	1.019	1.019	1.018	1.017	1.017	1.016	1.015	1.015	1.014	1.014	1.014	1.014	1.013	1.013	1.013	1.012	1.012	1.011	1.011
46	1.023	1.022	1.022	1.021	1.020	1.018	1.018	1.017	1.016	1.016	1.015	1.015	1.014	1.014	1.013	1.013	1.013	1.012	1.012	1.012	1.011	1.011	1.010	1.010	1.010	1.010
48	1.020	1.019	1.019	1.018	1.017	1.016	1.015	1.014	1.014	1.013	1.013	1.013	1.012	1.012	1.011	1.011	1.011	1.011	1.011	1.010	1.010	1.010	1.009	1.009	1.008	1.008
50	1.017	1.016	1.016	1.015	1.014	1.013	1.013	1.012	1.012	1.011	1.011	1.011	1.010	1.010	1.009	1.009	1.009	1.009	1.009	1.008	1.008	1.008	1.007	1.007	1.007	1.007
52	1.014	1.013	1.012	1.012	1.011	1.010	1.010	1.009	1.009	1.009	1.009	1.009	1.008	1.008	1.007	1.007	1.007	1.007	1.007	1.006	1.006	1.006	1.005	1.005	1.005	1.005
54	1.010	1.010	1.009	1.009	1.008	1.007	1.007	1.007	1.007	1.007	1.006	1.006	1.006	1.006	1.005	1.005	1.005	1.005	1.005	1.004	1.004	1.004	1.003	1.003	1.003	1.003
56	1.007	1.007	1.006	1.006	1.005	1.005	1.005	1.005	1.005	1.005	1.004	1.004	1.004	1.004	1.003	1.003	1.003	1.003	1.003	1.002	1.002	1.002	1.002	1.002	1.002	1.002
58	1.003	1.003	1.003	1.003	1.003	1.002	1.002	1.002	1.002	1.002	1.002	1.002	1.002	1.002	1.001	1.001	1.001	1.001	1.001	1.001	1.001	1.001	1.001	1.001	1.001	1.001
60	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
62	0.997	0.997	0.997	0.997	0.997	0.997	0.997	0.998	0.998	0.998	0.998	0.998	0.998	0.998	0.998	0.998	0.998	0.998	0.998	0.998	0.998	0.998	0.998	0.999	0.999	0.999
64	0.993	0.993	0.994	0.994	0.994	0.994	0.995	0.995	0.995	0.995	0.996	0.996	0.996	0.996	0.996	0.996	0.996	0.996	0.996	0.997	0.997	0.997	0.997	0.997	0.997	0.997
66	0.991	0.990	0.990	0.990	0.991	0.992	0.992	0.993	0.993	0.993	0.993	0.993	0.993	0.994	0.994	0.995	0.995	0.995	0.995	0.995	0.995	0.995	0.995	0.996	0.996	0.996
68	0.986	0.986	0.987	0.987	0.988	0.989	0.990	0.990	0.990	0.990	0.991	0.991	0.991	0.992	0.992	0.993	0.993	0.993	0.993	0.994	0.994	0.994	0.994	0.994	0.994	0.994
70	0.983	0.983	0.984	0.984	0.985	0.986	0.987	0.988	0.988	0.988	0.989	0.989	0.989	0.990	0.990	0.991	0.991	0.991	0.991	0.992	0.992	0.992	0.992	0.993	0.993	0.993
72	0.979	0.980	0.981	0.981	0.982	0.983	0.984	0.985	0.986	0.986	0.987	0.987	0.987	0.988	0.988	0.989	0.989	0.989	0.989	0.990	0.990	0.990	0.991	0.991	0.992	0.992
74	0.976	0.976	0.977	0.978	0.980	0.980	0.982	0.983	0.983	0.984	0.985	0.985	0.985	0.986	0.986	0.987	0.987	0.987	0.987	0.988	0.989	0.989	0.989	0.990	0.990	0.990
76	0.972	0.973	0.974	0.975	0.977	0.978	0.979	0.980	0.981	0.981	0.982	0.982	0.983	0.984	0.985	0.986	0.986	0.986	0.986	0.987	0.987	0.987	0.988	0.988	0.989	0.989
78	0.969	0.979	0.970	0.972	0.974	0.975	0.977	0.978	0.978	0.979	0.980	0.980	0.981	0.982	0.983	0.984	0.984	0.984	0.984	0.985	0.986	0.986	0.986	0.987	0.987	0.987
80	0.965	0.966	0.967	0.969	0.971	0.972	0.974	0.975	0.976	0.977	0.978	0.978	0.979	0.980	0.981	0.982	0.982	0.982	0.982	0.983	0.984	0.984	0.985	0.985	0.986	0.986
82	0.961	0.963	0.963	0.966	0.968	0.969	0.971	0.972	0.973	0.974	0.975	0.976	0.977	0.978	0.979	0.980	0.980	0.980	0.980	0.981	0.982	0.983	0.983	0.984	0.984	0.985
84	0.957	0.959	0.960	0.962	0.965	0.966	0.968	0.970	0.971	0.972	0.974	0.974	0.975	0.976	0.977	0.978	0.979	0.979	0.979	0.980	0.981	0.981	0.982	0.982	0.983	0.983
86	0.954	0.956	0.956	0.959	0.961	0.964	0.966	0.967	0.968	0.969	0.972	0.971	0.972	0.973	0.975	0.976	0.977	0.977	0.977	0.978	0.979	0.980	0.980	0.981	0.981	0.982
88	0.950	0.952	0.953	0.955	0.958	0.961	0.963	0.965	0.966	0.967	0.969	0.969	0.970	0.971	0.973	0.974	0.975	0.976	0.976	0.977	0.978	0.978	0.979	0.979	0.980	0.980
90	0.946	0.949	0.949	0.952	0.955	0.958	0.960	0.962	0.963	0.964	0.967	0.967	0.968	0.969	0.971	0.972	0.973	0.974	0.974	0.975	0.976	0.977	0.977	0.978	0.978	0.979
92	0.942	0.945	0.946	0.949	0.952	0.955	0.957	0.959	0.960	0.966	0.964	0.965	0.966	0.967	0.969	0.970	0.971	0.972	0.972	0.973	0.974	0.975	0.975	0.976	0.977	0.977
94	0.938	0.941	0.942	0.946	0.949	0.952	0.954	0.957	0.958	0.959	0.962	0.962	0.964	0.965	0.967	0.968	0.969	0.970	0.970	0.971	0.972	0.973	0.974	0.975	0.975	0.975
96	0.935	0.938	0.939	0.942	0.946	0.949	0.952	0.954	0.955	0.957	0.959	0.960	0.961	0.963	0.965	0.966	0.967	0.968	0.968	0.970	0.971	0.972	0.972	0.973	0.974	0.975
98	0.931	0.934	0.935	0.939	0.943	0.946	0.949	0.952	0.953	0.954	0.957	0.957	0.959	0.961	0.963	0.964	0.965	0.966	0.966	0.968	0.969	0.970	0.971	0.972	0.972	0.973
100	0.927	0.930	0.932	0.936	0.940	0.943	0.946	0.949	0.950	0.952	0.954	0.955	0.957	0.959	0.961	0.962	0.963	0.964	0.964	0.966	0.967	0.968	0.969	0.970	0.971	0.972
105	0.918	0.920	0.923	0.927	0.932	0.935	0.939	0.943	0.943	0.946	0.949	0.949	0.951	0.954												
110	0.907	0.911	0.913	0.918	0.923	0.927	0.932	0.936	0.937	0.939	0.943	0.944	0.946	0.949												
115	0.897	0.902	0.904	0.910	0.915	0.920	0.925	0.930	0.930	0.933	0.937	0.938	0.940	0.944												
120	0.887	0.892	0.894	0.900	0.907	0.912	0.918	0.923	0.924	0.927	0.931	0.932	0.934	0.938												
125	0.876	0.881	0.884	0.890	0.898	0.903	0.909	0.916	0.916	0.920	0.925	0.925	0.928	0.933												
130	0.865	0.871	0.873	0.880	0.888	0.895	0.901	0.908	0.909	0.913	0.918	0.919	0.923	0.927												
135	0.854	0.861	0.863	0.871	0.879	0.887	0.894	0.901	0.903	0.907	0.912	0.913	0.916	0.921												
140	0.842	0.850	0.852	0.861	0.870	0.879	0.886	0.893	0.895	0.900	0.905	0.907	0.910	0.915												

FIGURE 4

Reduction of Observed Specific Gravities to Specific Gravities at 60°F./60°F. (N.G.A.A., 1942)

| °F. | SPECIFIC GRAVITY AT INDICATED TEMPERATURE | | |

The foregoing data—particularly that for Blend 1 —do not permit the conclusion that the two component mixtures behave as perfect solutions. Nevertheless even for this blend temperature-volume factors at 100° F. based on the observed, and the calculated densities vary by less than two units in the third decimal place being respectively .9422 and .9403. Based on these results, which confirmed previous investigations in the laboratories of a member company, it was concluded that for the commercial liquefied petroleum gas products, densities and volume factors at various temperatures could be ascertained by interpolating between the values for the pure compounds using the density or specific gravity of the mixture at 60° F. to identify it. The Bureau of Standards[11] has used this same method in applying the earlier work of Dana to this problem.

Accordingly a graph was prepared plotting the data iso-thermally with respect to specific gravity (density) at 60° F. The correlation with specific gravity is considered commercially accurate for the liquefied petroleum gas products—which usually consist of two or three closely related components, over the entire temperature range —50 to 140° F. Beyond the liquefied petroleum gas range, i.e., for specific gravities above 0.600, the correlation is likewise considered commercially accurate for the narrower temperature range 0-100° F. By commercially accurate is meant that the volume-correction factors will be correct to one unit in the third decimal place. For the extreme temperature range —50 to 0° F. and 100-140° F. and above .600 specific gravity the data are less accurate but perhaps represent the best information available in these ranges. In the tabulation of volume-correction factors, Figure 4, the data have been adjusted to a specific gravity (hydrocarbon at 60 with reference to water at 60) base to be consistent with NGAA Method for Determining Specific Gravity of liquefied petroleum gas. In Figure 5 the tabular data are again based on specific gravity at 60/60 consistent with Association standards.

TABLE 8
Correlation of Experimental Density Data With That of Dana et al[1]
(gm/ml)

	Propane			Isobutane			Normal Butane		
° F.	Dana	This Work	Diff. ×10⁻⁴	Dana	This Work	Diff. ×10⁻⁴	Dana	This Work	Diff. ×10⁻⁴
140	.....	.....	.....	.5046	.5036	10.	.5284	.5293	9.
120	.4533	.4527	6.	.5206	.5196	10.	.5441	.5440	—1.
110	.4639	.4625	14.	.5286	.5272	14.	.5513	.5509	—4.
90	.4829	.4813	16.	.5430	.5417	13.	.5646	.5644	—2.
80	.4918	.4903	15.	.5502	.5488	14.	.5711	.5710	—1.
70	.5004	.4990	14.	.5574	.5556	18.	.5777	.5774	—3.
60	.5086	.5074	12.	.5638	.5625	13.	.5839	.5838	—1.
50	.5164	.5157	7.	.5702	.5692	10.	.5899	.5900	1.
40	.5243	.5234	9.	.5766	.5757	9.	.5958	.5961	3.
30	.5318	.5311	7.	.5830	.5821	9.	.6014	.6021	7.
20	.5393	.5387	6.	.5895	.5884	11.	.6070	.6082	12.
10	.5465	.5456	9.	.5959	.5947	12.	.6126	.6138	12.
0	.5533	.5522	11.	.6023	.6008	15.	.6182	.6196	14.
—10	.5600	.5592	8.	.6079	.6067	12.	.....	.....	...
—20	.5666	.5660	6.	.6143	.6127	16.	.....	.....	...
—30	.5731	.5728	3.	.....	.....	...	.....	.....	...
—40	.5797	.5794	3.	.....	.....	...	.....	.....	...
—50	.5863	.5858	5.	.....	.....	...	.....	.....	...

TABLE 9
Comparison of Experimental Density Data With Values Found in the Literature
(gm/ml)

	Propane		Isobutane		Normal Butane		Normal Pentane	
° F.	Lit.	This Work	Lit.	This Work	Lit.	This Work	Lit.	This Work
122	.449[10]	.4506	.5183[10]	.5182	.5422[10]	.5425	.....	....
113	.459[10]	.4595	.5233[10]	.5249	.5484[10]	.5488	.....	....
104	.467[810]	.4682	.5321[10]	.5315	.5544[10]	.5551	.....	....
95	.476[810]	.4768	.5386[10]	.5380	.5604[10]	.5612	.....	....
86	.484[810]	.4850	.5450[10]	.5445	.5665[10]	....	.....	....
77.5	.....	.....	.5530[4]	.5504	.....	.....	.....	....
77	.492[910]	.4929	.5513[10]	.5507	.5723[10]	.5731	.....	....
68	.....	.....	.5592[3]	.5569	.5788[5]	.5787	.....	....
68	.500[410]	.5007	.5575[10]	.5569	.5780[10]	.5787	.626383	.6260
69	.507[310]	.5074	.5630[10]	.5625	.5826[10]	.5838	.....	....
59	.....	....	.....	.....	.....	....	.631147	.6309
53	.....	....	.5691[4]	.5671	.....	.....	.....	....
50	.515[010]	.5157	.5695[10]	.5692	.5888[10]	.5901	.63599	.6357
39.8	.....	....	.5787[4]	.5758	.....	....	.....	....
32	.....	....	.....	.....	.....	.....	.6453[6]	.6454
31.1	.....	....	.....	.....	.60174	.6015	.....	....
29.6	.....	....	.5845[4]	.5823	.....	....	.....	....
20.8	.....	....	.5899[4]	.5878	.....	....	.....	....
14	.....	....	.....	.....	.....	....	.6545[8]	.6549
11.8	.....	....	.5927[4]	.5936	.....	....	.....	....
3.6	.....	....	.6005[4]	.5986	.....	....	.....	....
— 5.2	.....	....	.6055[4]	.6038	.....	....	.....	....
—18	.....	....	.6131[4]	.6115	.....	....	.....	....
—22	.....	....	.....	....	.....	....	.67288	.6730
—44	.5824[3]	.5819	.....	....	.....	....	.....	....
—44	.5829[2]	.5819	.....	....	.....	....	.....	....

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Keep Your Arc Welders Welding

R. F. WYER, Welding Engineer, General Electric Company

Amp.	Speed	Make	Connection Diagram	Application	Shop or Mill No.	Card No.
Type	Motor Voltage		Time or Duty Cycle		F.L. Amp.	Phase / Cycles

Serial No. / Model No.	Publication No.		Mfr's Order No. / Our Order No. / Date of Order / Cost
BRUSHES: No. / Cat. No. / Size / Material / Grade	COILS (Cat. or Spec. No.) Motor: Stator: Main / Comm. / Comp.	Generator: Field: Main / Comm. / Comp.	
BEARINGS: Front End, Cat. No. / Motor End, Cat. No.	Rotor: Coils / Bars / No. per set	Armature: Coils / Bars / No. per set	User: / Location:

SERVICE RECORD

Date	Shop	Floor	Service (Tacking, etc.)	Duty Factor	Tested Load: Volts	Amps

REPAIRS

Date	Condition	Due to	Repaired by	Cost

MAINTENANCE

Greased: Date	By	Inspected: Date	By	Cleaned: Date	By

Card records of every welder in the plant save time and money. Recordings made after inspection and service indicate any welder requiring excessive expense, and causes can be corrected before an emergency occurs.

WHILE arc-welding sets today represent the highest in simplicity and reliability, they will require periodic attention from a maintenance standpoint if they are to be kept in the best operating condition.

With the accent on production in welding shops of all types, failure of even a few sets is sometimes costly. A systematized maintenance program will pay dividends in terms of better welder performance and longer life.

The right welding set must be selected for the job, because a maintenance program will be discouragingly difficult if misfit equipment is being used.

To insure proper choice of the rating of a single-operator set, the maximum current, load voltage, and duty factor (ratio of arc time to total time) must be taken into account. Except in the smallest sizes, most sets are rated on a one-hour load. Their rating is the current which they will deliver for one hour without interruption, without exceeding a prescribed temperature rise.

Since this method of rating, chosen as a simple standard for comparison, does not take into account actual operating conditions, it is not always economically sound to choose the size next larger than the maximum operating current contemplated. However, for this same reason duty factor should be taken into account when new equipment is being considered to make certain that the set is big enough for the job.

Proper installation can do much to keep the welding equipment at work and troubles to a minimum. In wiring up a welding set, care should be taken to provide adequate branch circuit conductors, and fuse clips large enough to accommodate the necessary fuses. It should be observed that motor-generator-type welding equipments have full-voltage motor starters almost without exception, so that due consideration must be given to the starting current of the motors.

Care should be taken to ground the frames of all welding equipments in order to avoid shock or annoying tickles when a grounded person touches the frame of the equipment. Even with equipment in perfect operating condition, under some conditions it is possible to receive a harmless but irritating sensation of shock from ungrounded equipment due to the passage of infinitesimal capacity or leakage currents. In addition to protecting against this annoyance, adequate grounding of machine frames is also a desirable safety precaution against harm resulting from insulation failure in equipment or leads, or improper connections.

Regardless of the type of safety ground connection which is installed, adequate low-resistance-work leads should always be used, and care should be taken to secure good connection between the work lead and the work. If this is not done, it is possible

under some circumstances to overheat the safety ground connection by the passage of welding current through it.

In the location of welding equipment, ventilation is a very important consideration. The life of electrical insulation is seriously shortened by overheating, and overheating is bound to result where insufficient ventilation is provided. Particularly where large numbers of welding equipments are to be located in small enclosures, considerable study should be given to the problem of supplying clean, cool ventilating air. Where small houses or temporary sheds are located in hot sunshine, the heat absorbed from the sun added to the heat dissipated by the welding equipments may raise the ambient temperature above 100° F. and cause severe overheating. In such cases, large louvers or other ventilating openings should be provided in the building not only at the bottom but near the roof to give good air circulation and keep the ambient temperature below 100° F. In some instances, it is desirable to provide exhaust fans to assist in removing heated air from the upper part of such enclosures.

Inspection and Regular Servicing

The competent maintenance man will have a record of all welders under his care. One of the most useful and easy-to-handle references is a card file. All repair work, with its cost, can be entered on the record, and any welder requiring excessive attention or expense can be investigated and causes determined and corrected.

Inspection records will also serve as a guide to tell when welders should be replaced because of the high cost to keep them in operating condition. Misapplications, abuses, and the like will also be disclosed.

Periodic Inspection

A systematic and periodic inspection of motors and generators is necessary to insure best operation. While some welders are installed where conditions are ideal—where dust, dirt, and moisture are not present to an appreciable degree—most machines are located where some sort of dirt accumulates on the windings. This lowers insulation resistance and cuts down creepage distances.

Steel-mill dusts are usually highly conductive, if not abrasive, and lessen creepage distances. Other dusts are highly abrasive and actually cut the insulation in being carried through by the ventilating air. Fine cast-iron dust quickly penetrates most insulating materials.

Hence the desirability of inspecting motors periodically. If conditions are extremely severe, weekly inspection and partial cleaning are desirable. Most motors require a complete overhauling and thorough cleaning about once a year.

Once a Week

For the weekly cleaning, the motor and generator should be blown out with dry compressed air (about 25 to 30 pounds per square inch in pressure). Where conducting and abrasive dusts are present, even lower pressure may be necessary, and suction is to be preferred, as damage can easily be caused by blowing the dust and metal chips into the insulation. On most motors the windings are fairly accessible, however, and the air can be properly directed to prevent such damage.

About once a year, welders should be overhauled. First, the heavy dirt and grease should be removed with a heavy, stiff brush, wooden or fiber scrapers, and cloths. Rifle-cleaning bristle brushes can be used in air ducts. Dry dust and dirt can be blown off, using dry compressed air at moderate pressure. Care must be taken to direct the air so that the dust will not cause damage and will not be pocketed in the various corners. Grease, oil, and sticky dirt are easily removed by applying cleaning liquids such as carbon tetrachloride.

If the welder can be spared from service long enough, the insulation of the motor should be dried out by heating to from 90 to 100° C. While the motor is still warm, a high-grade insulating varnish should be applied.

The varnish may be sprayed or brushed on. After applying the varnish, the best results are obtained by baking for 6 to 7 hours at about 100° C. If the machine must be put back into service quickly, or if facilities are not available for baking, fairly good results will be obtained by applying one of the varnishes which dry in a few hours at ordinary room temperatures.

Lubrication

Manufacturers' instructions regarding lubrication of bearings should be carefully noted. These instructions should be kept near the welder so that they are readily accessible. Usually grease-packed bearings have sufficient lubricant when shipped from the factory to last about a year under normal conditions of cleanliness and temperature. When sets are operated in unusually dirty atmospheres, run continuously 24 hours per day, or exposed to extremes of temperature, it would be well to shorten the bearing inspection and lubrication interval down to six months, or less if experience warrants. An occasional check of bearing temperature by feeling with the hand may disclose undue heating before damage is actually done. Once a lubricating routine has been established, it should be carried out, and by reliable men who will follow instructions.

It is pretty generally established that outside of gross neglect for long periods, the major causes of bearing troubles are overgreasing and dirt. Overgreasing results in excessive heating of the bearing, frequently with churning and breaking down of the grease with consequent loss of its protective qualities.

Dirt occasionally gets into a bearing through the use of grease that is carried around or stored in uncovered containers. Quite as frequently it gets in through carelessness in protecting parts while bearings are disassembled or opened for inspection. The prevention is obvious but often overlooked:

1. Every part of a bearing assembly, including retainer plates, gaskets, and screws, should be placed in a clean box immediately on removal, and if dropped or otherwise soiled, should not be replaced without a thorough cleaning in a suitable solvent.
2. None but clean hands, tools, and rags should ever be allowed to touch a bearing.
3. Grease must be clean. If there is the slightest doubt of its purity, it should be thrown away. Grease is cheap compared with bearings and lost man-hours.

Only a high-grade of grease should be used for ball-bearing lubrication.

Brush inspection is important. The first essential requirement for the satisfactory operation of brushes is the free movement of the brushes in their holders. Uniform brush pressure also is necessary to assure equal current distribution. Adjustment of brush holders should be set so that the face of the holder is approximately ⅛ inch up from the commutator; any distance greater than ⅛ inch may cause brushes to wedge, resulting in chattering and excessive sparking.

It is essential that the correct grade of brush for a specific application be used. Recommendations as to the correct grade of brush should be obtained from the manufacturer of the welder only.

Broken brushes imply two possibilities: incorrect brush grade, or mechanical defects (such as unbalanced, rough, or eccentric commutator). To eliminate brush breakage, both factors should be corrected.

Check the brushes to make sure that they will not wear down too far before the next inspection. Keep extra sets of brushes available so that replacement can be made when needed. It is false economy to use brushes down to the absolute minimum length before replacement. Cases have been known where brushes have worn down until the metal, where the pigtail connects to the brush, was touching the commutator. This, of course, was causing damage to the commutator.

Make sure that each brush surface, in contact with the commutator, has the polished finish that indicates good contact, and that the polish covers all of the surface of the brush. When replacing a brush be sure to put it in the same brush holder and in its original position. It has been found helpful to scratch

Blowing dust out of welder should be done carefully with low-pressure air to avoid driving abrasive particles into insulation.

Sanding brushes to a good fit with the commutator is essential whenever new brushes are installed.

The megger is a convenient means of determining the condition of insulation by indicating its resistance to leakage currents.

a mark on one side of the brush when removing it, so that it will be replaced properly.

When installing new brushes, fit them carefully to the commutator. Sand only until the curve of the brushes is the same as that of the commutator. Be sure that the brush shunts (pigtails) are fastened securely so that current will not overheat the brushes and brush holders.

Check the springs that hold the brushes against the commutator. Improper spring pressure may lead to commutator wear and excessive sparking. Excessive heating may have annealed the springs, in which case they should be replaced and the cause of heating corrected.

Commutators

Inspect the commutator for color and condition. It should be clean, smooth, and glossy, with a color varying from straw to chocolate brown where the brushes ride on it. A bluish or reddish color indicates overheating of the commutator. Roughness of the commutator should be removed by sandpapering or stoning. Never use emery cloth or an emery stone. Use a "fine" stone or number 00 sandpaper unless the commutator is in bad condition, when the job may be started with a "coarse" stone and finished with "fine."

For this operation, press the stone or sandpaper against the commutator with moderate pressure with the motor running, and move it back and forth across the commutator surface. Use care not to come in contact with the live parts. Be sure to keep the dust out of the machine.

If the commutator is very rough as evidenced by pronounced up and down vibration of the brushes,

Hand-operated grease guns should always be used on pressure - relief lubricated bearings. Grease should be added slowly to permit excess to vent from relief pipe or plug. (Latter not visible here.)

Common Arc-Welder Troubles and Their Remedies

TROUBLE	CAUSES	WHAT TO DO
Machine Fails to Hold Heat:	Rough or dirty commutator	Commutator should be trued or cleaned
	Brushes may be worn down to limit of adjustment or life	Replace or readjust brushes
	Brush springs may have lost adjustment or may be broken	Replace or readjust brush springs
	Field circuit may have variable resistance connection or intermittent open circuit	Check field current with ammeter to discover varying current. This applies to both the main generator and exciter if used
	Electrode lead or work lead connections may be poor	Tighten all connections
	Wrong grade of brushes may have been installed on generators	Check with manufacturer's recommendations
	Field rheostat or tap switches may be making poor contact and overheating	Inspect rheostat and clean and adjust finger tension on switches
	Brush-shifting or other mechanical current-adjusting mechanism may have loose or worn links	Check current-adjusting mechanism for back-lash and play
Motor Trips Off Line:	Power circuit may be single-phased	Check for one blown fuse or dead line
	Welder may be operating above current capacity	Check load against welder nameplate Check duty cycle
	Welding electrode or work leads may be too long or too small in cross section	Check terminal voltage while machine is loaded; it should not exceed 30 volts on small machines or 40 volts on large machines when operating at rated current
	Ambient temperature may be too high	Make sure that temperature in motor-generator room or housing does not exceed 100° F. and that there is no interference with normal ventilation of the machine
Machine Fails to Start:	Power circuit may be completely dead	Look for open disconnect switch, fuses removed from clips, or blown fuses
	Power circuit may be single-phased	Look for one blown fuse or one dead line
	Power line voltage may not be suitable for motor, or may be extremely low; may be accompanied by chattering of the motor starter	Check voltage with voltmeter, particularly at the moment of attempted starting
	Machine may be jammed	See that armature turns over easily by hand, and look for foreign material in air gaps
	Motor starter may be single-phased	Check to see that all fingers on starter make contact when closed
	Overload protecting relays may be tripped	See that relay contacts are closed and that starter picks up when push button is pressed. Be sure to remove cause of tripping
Welder Starts but Fails to Generate:	May be running the wrong way	Check direction of rotation with manufacturer's instructions or direction arrow. On 3-phase motors, direction of rotation may be changed by interchanging any two leads
	Generator or exciter brushes may be loose or missing	Be sure that all brushes bear on the commutator and have proper spring tension
	Exciter may not be operating	Check exciter output voltage with voltmeter or lamp
	Field circuit of generator or exciter may be open	Check for open circuits in rheostat, field leads, and field coils. Also check resistors and rectifiers, if any. Some machines give low output when fields are open.
	Generator may be reversed in polarity due to another machine or incorrect operation in parallel with another machine	*Flash the field with a storage battery or another generator first with one polarity and then with the other to see if it builds up (Flash exciter field if set has separate exciter)
	Series field and armature circuit may be open-circuited	Check circuit with ringer or voltmeter
Welding Arc is Loud and Spatters Excessively:	Current setting may be too high	Check setting and current output with ammeter Check polarity
	Polarity may be wrong	Try reversing polarity or try an electrode of the opposite polarity

* "Flashing" the field of a generator or exciter is a method of establishing the residual magnetism of the field structure with the proper polarity to cause the machine to "build-up," or generate voltage. It consists of passing a relatively heavy current through the field windings momentarily, using an external source of direct current to supply the power.

If a low-voltage source, such as a storage battery, is used, the series field of the generator should be flashed; if a higher voltage source such as another generator or exciter is used, the shunt field should be flashed.

the armature should be taken out and the commutator turned down in a lathe. When this is done, it is usually necessary also to cut back the insulation between the commutator bars slightly. If the commutator is found to be dirty when the generator is inspected, it should be wiped clean with a piece of canvas or other cloth that is free from lint.

Never put oil on the commutator. Proper selection of brushes gives the commutator all the lubrication required to prevent excessive wear and to build up a good smooth operating glazed surface on the copper. The addition of oil results in the development of a high-resistance film which may cause undue heating and rough brush action. The oil will also have a detrimental effect on the internal parts of the commutator.

Transformers

The arc-welding transformers of alternating-current welders require a minimum of maintenance, but this fact should not be allowed to result in neglect. On fan-cooled units, fans should be cleaned and lubricated about once a year. Windings should be blown out at least twice a year in very clean locations, and more often in dusty places. At the time of this periodic attention, all connections and coil supports should be checked for tightness. Manual current adjusting mechanisms should be lubricated often enough to prevent stiff operation of the handwheel or crank, making sure that a fairly-high-melting-point grease is uniformly distributed over the full length of screws and guides. On motor-operated controls, lubrication at more frequent intervals may be required, as evidenced by slowing down of the motor or noise from the gearing. This point should be checked at least three times a year, and more often if experience justifies it.

Abuses

While most welding equipment is designed to stand up under unusually adverse operating conditions, some not infrequent circumstances will cause serious impairment if not complete interruptions of their service.

One bad practice, for example, is that of leaving weather-protecting tarpaulins thrown over machines in operation, in such a way as to interfere with the free passage of ventilating air into and out of the equipment. Cases are known where welders have been equipped with canvas flaps permanently installed on inlet and exhaust air openings, resulting in severe overheating and very short equipment life.

Improper connection of extension leads for either the electrode or work terminals is not at all uncommon. This results in a high resistance circuit from welder to arc and return with resulting variations in welding current, particularly when the leads are moved so as to change the resistance of the connections. This is a frequent cause of complaints by welding operators that the heat is not steady. The remedy for this is to make sure that connections are kept tight, and that all connections are made with cables equipped with properly installed cable lugs or terminals. It is practically impossible to bolt or wedge untinned flexible cable to another conductor and secure a good low-resistance joint. Soldered or reliable solderless connectors or terminals should always be used.

The use of excessively long electrode or work leads with motor-generator-type welders will result in overheating of the motor when operating in the upper part of the current range unless extraordinarily large cables, or a number connected in parallel, are used. Overheating of the motor from this cause is a frequent reason for motor-generator welders tripping off the line with consequent loss of production.

A source of trouble which is not protected against by the motor overload relays is the intentional or unintentional application of long continued short circuits on the generator. Poor cable or cable connection insulation may be responsible for unintentionally short circuiting a generator for long periods. This results in the flow of very heavy generator current, but because of the low generator voltage involved, does not require sufficient power input from the line to cause the motor overload relay to trip. While the motor is not damaged, the generator may be seriously overheated or burned out. The same results will follow intentional permanent short circuiting of the electrode holder on the work or any grounded conductors.

The use of improperly bonded structural steel systems or building frameworks for the welding current return circuit is undesirable. The high resistance path thus afforded the welding current may result in overheating of the welder motor, and in addition, there is always the possibility that arcing or overheating of some poor connection, possibly quite remote from the scene of operations, may go unnoticed and start a fire.

No attempt should be made to adjust welding current output by any means other than those provided and recommended by the manufacturer of the equipment. Shifting the brushes on generators not designed for brush-shifting control usually will result in inferior welding characteristics, impaired commutation, and short brush life. Short circuiting of resistors or rheostats or any other tampering with the control furnished on arc welding equipment may result in damaging or burning out the equipment.

In transporting welding equipment, rough handling resulting in permanent mechanical damage is all too frequent. Motor-generator sets mounted on steel-wheeled running gear should be moved only at slow speeds—never behind fast-moving trucks or other vehicles. They should be eased over obstacles and depressions such a flange clearance grooves in tracks. Slings used for transportation of welders by crane should be carefully arranged to avoid damaging control boxes, handles, and other equipment mounted on the outside of the set.

Care should be taken to avoid using arc welders out-of-doors in unfavorable weather. Many machines now on the market are designed to be both semi-protected and drip proof. This does not mean, however, that these welders should be used in rain or other precipitation without suitable protection.

At the discretion of the user, of course, drip proof or even open motor-generator sets can be operated out-of-doors, provided they are protected from obviously damaging conditions by tarpaulins or temporary shelters. These must be arranged so as not to hinder ventilation of the equipment, as previously discussed.

Common Troubles and Their Remedies

In spite of the reliability of the modern arc welder, troubles will occur. The causes and remedies for the majority of such troubles are given in the accompanying tabulation.

What is the Sharples stake in the petroleum industry?

Here are the Facts

Production of Sharples centrifuges is currently running nine times the average of the prewar decade. At the present writing 89½% of these machines are to be used partly in the refining of petroleum and principally in the maintenance of its purity during use. . . . Where the use of centrifugal force is indicated, nothing can compete with its effectiveness.

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Effect of War Impact on Refinery Yields

REPORTS showing that refineries in Districts 1, 2 and 3 were facing income losses of as high as $35,000 a day as a result of changes in yields to produce products needed for the war, that the East Coast situation has not improved greatly and faced a difficult winter, an assertion that a definite program of government participation in the discovery and development of new fields was needed, and a controversy over proposals for the pooling of excess materials marked the September meeting of the Petroleum Industry War Council.

The heavy losses faced by refining were brought out in a report of the Committee on Petroleum Economics, which developed also that consumption of gasoline in the rationed area has not yet been brought down to the 435,000 barrels daily aimed at and warned that under the best of circumstances the East will go into the winter season with but a slight margin of safety of supply and inventory over demand in sight.

An important report on the impact of the war on the industry was submitted to the meeting, but after considerable discussion was returned to the committee in charge with instruction to revise and resubmit it next month. The report was not made public, but is understood to have dealt in detail with the problem of excess transportation costs which now has been cleared up by the agreement of the Defense Supplies Corporation to assume that burden.

Equipment Distribution

A sharp difference of opinion as to how surplus materials in the industry should be made available to those needing them arose at the last of the two-day sessions when charges were made that in some instances there has been an attempt to hoard such materials and an insistence that any plan for pooling should take that charge into consideration. There was considerable opposition to anything drastic, and the council finally adopted a resolution expressing the belief that "it is essential that all necessary materials and supplies required for the exploration and production of petroleum be made available on an equitable basis to all production units of the petroleum industry wherever possible," and asking the Coordinator to set up in each district a committee on materials and supplies which would be impowered to take the steps necessary to bring about through industry cooperation, equitable distribution of such materials as may now exist. The committee also would be directed to prepare and submit to OPC estimates of future materials requirements, so that OPC and WPB may properly adjust the flow of materials from manufacturing sources.

Through this resolution the council avoided definite action on any of the several plans proposed for achievement pooling, all of which were subject to opposition, and left the way open for each district to develop the plan which the various interests felt best fitted to conditions in the area.

East Coast Deliveries

Strenuous efforts of the industry have resulted in increasing East Coast stocks of crude oil and products by 6,600,000 barrels during the past eight weeks, but have failed by 25 percent to achieve the increase needed to provide the required minimum accumulation of distillate and residual-fuel oil stocks, PIWC was told in a report of its committee on petroleum economics.

With the favorable summer weather fast drawing toward a close, the committee saw little chance of providing any broad margin of safety in stocks, and called for the most effective utilization of transportation and the utmost flexibility in providing a maximum yield of fuel oils during the next few months to boost supplies as much as possible.

At the same time, "in view of the small margin of safety and the limited flexibility offered," the committee called for a re-examination of the whole East Coast program "from a practical oper-

PIWC Refinery Yield Program

(Figures are percent yield of crude runs to stills)

	Actual 1941	SUPPLY PROGRAM FOR 1942 August	1942 September	1942 4th Quarter	1st Quarter 1943
District 1:					
Gasoline	39.3	37.6	35.5	35.0	35.0
Kerosene	4.7	4.5	4.0	3.8	3.8
Distillate Fuel	17.6	9.3	13.3	14.3	14.3
Residual Fuel	21.2	26.6	27.4	27.7	28.4
Lubricants	5.8	8.2	7.2	6.9	6.9
Asphalt and Road Oil	5.0	2.7	2.2	1.9	1.1
Other and Loss	6.4	11.1	10.4	10.4	10.5
Total	100.0	100.0	100.0	100.0	100.0
District 2:					
Gasoline	52.2	44.0	43.0	40.4	40.0
Kerosene	5.0	7.0	7.0	7.0	7.0
Distillate Fuel	10.3	13.7	14.7	17.8	17.0
Residual Fuel	18.5	22.0	22.0	22.0	23.0
Lubricants	2.2	2.4	2.4	2.4	2.4
Asphalt and Road Oil	3.6	4.5	4.0	3.1	2.6
Other and Loss	8.2	6.4	6.9	7.3	8.0
Total	100.0	100.0	100.0	100.0	100.0
District 3:					
Gasoline	44.4	34.8	33.8	33.8	33.8
Kerosene	7.4	6.0	5.4	5.4	5.4
Distillate Fuel	14.2	17.0	17.4	17.4	17.4
Residual Fuel	23.2	29.4	29.4	29.4	29.4
Lubricants	2.5	2.5	2.4	2.4	2.4
Asphalt and Road Oil	1.5	1.7	1.6	0.8	0.6
Other and Loss	6.8	9.6	10.0	10.8	11.0
Total	100.0	100.0	100.0	100.0	100.0
Refinery Crude Runs—(Thousands of Barrels per Day)					
District 1	667	550	625	650	650
District 2	1117	1170	1170	1150	1150
District 3	1359	1205	1250	1250	1250
Total	3143	2925	3045	3050	3050

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2 **UNIFORM GASKET PRESSURE ASSURED** by accurate finishing of the retaining surfaces to very close tolerances.

3 **EQUAL RESILIENCE ON BOTH SIDES OF GLASS** due to interchangeable gaskets which also eliminate possibility of improper reassembly in field.

4 Spacing band centers glass and prevents contact with metal.

5 **PERFECT GASKET JOINTS WITH MINIMUM BOLT TENSION** because misalignment of parts is impossible, which also eliminates frequent cause of glass breakage.

6 **DISTORTION PREVENTED** by reinforcing beam and scientific distribution of metal in frame. (Distortion causes excessive strains in glass and results in breakage.)

7 **GASKET BLOW-OUTS PREVENTED** by full metal backing of entire surface and periphery of both gaskets.

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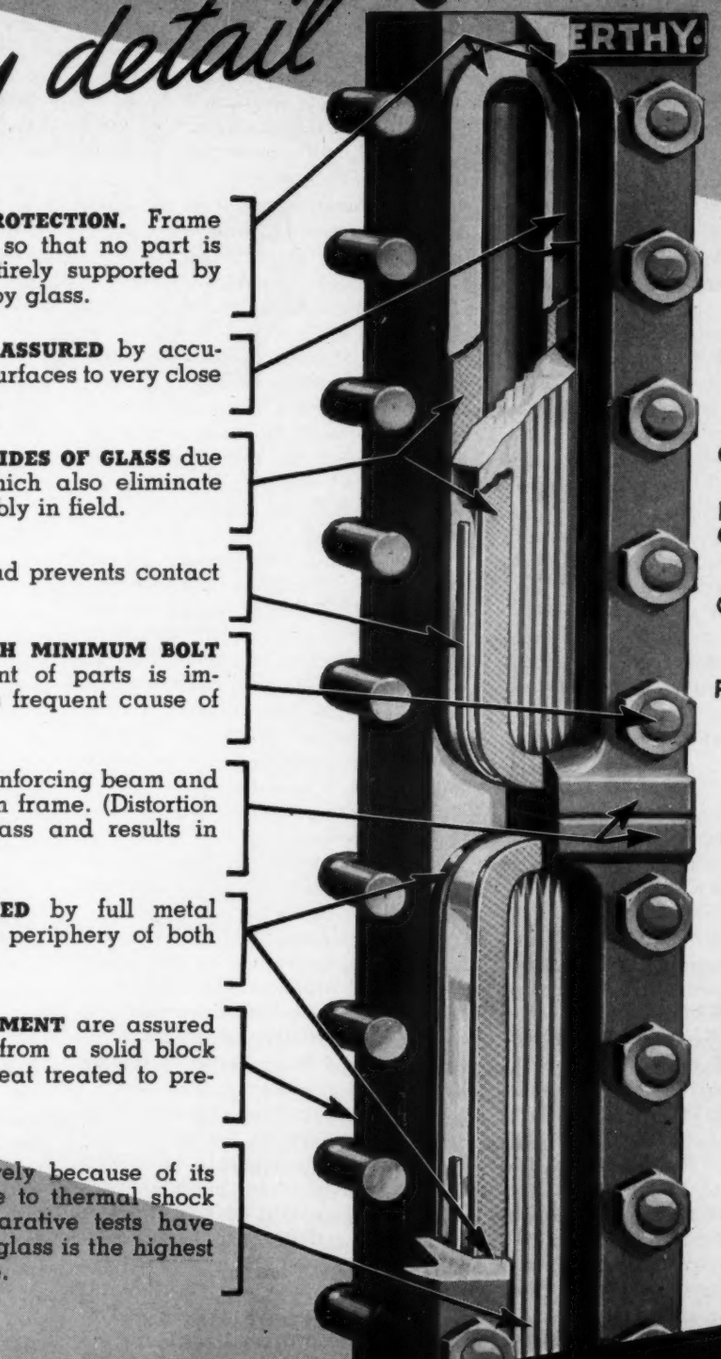

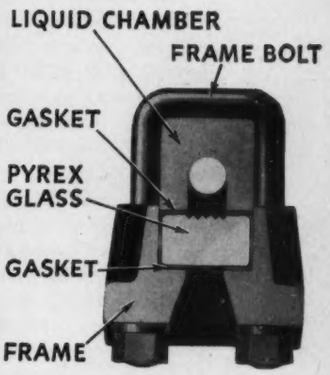

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ating standpoint" and declared that "if the margin of safety and operating flexibility are inadequate, or if the program outlined cannot be made effective promptly, in view of uncertainty as to compensation for the large operating losses it would involve, additional steps would have to be taken."

Because of the drain upon the facilities of other areas to satisfy District 1 needs, the committee considered supply and demand not only in that district but in Districts 2 and 3, and the extent to which the East might be supplied from District 2.

Its estimates, assuming tanker deliveries of 150,000 barrels a day, placed August Eastern deliveries at 1,272,000 barrels, plus 83,000 barrels of crude oil and natural gasoline produced in the district, a total supply of 1,355,000 barrels daily, or 236,000 barrels more than demand.

This month, however, it is figured tanker deliveries will drop to 125,000 barrels, but tank-car deliveries will increase from 850,000 to 970,000 barrels a day, with crude production also up 1000 barrels and deliveries by other means increased, to give a total supply of 1,472,000 barrels, or 284,000 more than the demand scheduled to be supplied.

Beginning with October, tanker deliveries will drop to 100,000 barrels a day, tank-car deliveries will begin to feel the effects of tougher railroad operating conditions and Great Lakes tonnage will decline, although District 1 production of crude oil will reach a peak of 80,000 barrels, and natural gasoline will increase to 7000 barrels, and further to 9000 barrels by November. As a result, deliveries are expected to drop to 1,291,000 barrels a day next month, 1,285,000 barrels in November and 1,250,000 barrels in December, while the change in inventories will drop to 112,000 barrels more than scheduled demand in October, to 37,000 barrels less than demand in November and 204,000 barrels less than demand in December.

For the first quarter of next year, however, the picture is brighter, for tank-car deliveries are estimated to rise to 932,000 barrels a day, pipe-line deliveries will reach 95,000 barrels of crude and 91,000 of products, and barge movement on the Mississippi and Ohio will run to 88,000 barrels and to Florida 81,000 barrels, giving total receipts, with no estimate whatever for tanker deliveries, of 1,287,000 barrels. But scheduled demand and deliveries to other districts—chiefly lubricating oils—will be 139,000 barrels more than receipts.

On the whole, the committee said, this program will provide sufficient supplies to the East Coast to cover essential demands with a small surplus of about 4 percent but, it was pointed out, "this leeway constitutes a negligible margin of safety considering present minimum stocks and the size of the operations involved, and even if realized would only take care of one third of the intermediate demand."

Realization of this program, the council was told, will necessitate prompt action on the following:

"(a) Maximum utilization of all available transportation facilities in the most effective manner. In particular, to realize the estimates of tank-car deliveries, upon which the success of the program depends, will mean a high degree of industry cooperation in the use of terminal and loading facilities to make possible maximum movement in train-load lots. To take care of the increase forecast in barge deliveries on the Ohio River, adequate additional barge unloading, storage and tank-car loading facilities must be provided.

"(b) A marked readjustment in refinery yields to increase distillate and residual fuel oil production at the expense of gasoline. This will mean the maximum utilization of refining flexibility. To avoid hardship on refiners which would jeopardize the program, and to expedite carrying out of the required changes, prompt action on the necessary compensation is essential.

"(c) Necessary cooperation by state regulatory bodies and the Interstate Compact Commission to make possible the crude production schedules indicated for the three districts.

"(d) The adjustment of refinery operations and transportation so that stocks of crude and products will conform to the schedules indicated, which take into account the variation in seasonal requirements and works down to seasonally adjusted minimum stocks.

"(e) The control of the use of all petroleum products in District 1 so as not to exceed the available supplies of each. It is particularly important that gasoline consumption be held down to the amount estimated to be available under the program. Failure to do this will mean the use, for gasoline, of transportation facilities that should be used to build up needed stocks of distillate and residual fuel oils in anticipation of increased winter demands.

"(f) Coordination between buyer and seller activities so that supplies offered in Districts 2 and 3 may promptly be moved to District 1 in such quantities and from such location as to utilize most effectively all available transportation.

"Too much stress cannot be placed upon the fact that the scheduled program offers only a very small margin of safety," the report concluded. "All areas and functions of the industry must cooperate to a high degree in order that the operating schedules indicated be put into effect promptly."

In its review of conditions, the report pointed out that in Districts 2 and 3 no artificial restrictions on consumption are assumed other than the effect of voluntary curtailment brought about by the scarcity of rubber and other factors. Gasoline consumption in District 2 is estimated as decreasing by December to 25 percent under the same month last year, but in District 3 overall gasoline demand is expected to increase because of the anticipated increase in aviation gasoline requirements.

For the two districts together the local demand for kerosine and distillate oil for the forecast period is seen as changing only nominally from a year ago, while in the case of residual fuel oil an increase of 19 percent over 1941 is foreseen.

Need More Yield Adjustments

Appended to the report was a table of refinery runs and yields forecast for the three districts, showing, it was pointed out, the marked adjustments that will have to be made to increase distillate and residual fuel oil supplies at the expense of gasoline.

"Additional residual fuel oil supplies are particularly needed because of increased war and industrial activity, while the consumption of gasoline is anticipated to continue to drop off as the result of rubber restrictions and of rationing in District 1," it was explained. "In the schedules of indicated yields, consideration has been given to the necessity of maintaining certain amounts of motor gasoline production in plants manufacturing essential war products. To accomplish these yield changes will utilize existing refinery flexibility to a maximum. Prompt action in this direction is required, for the longer the changes are delayed, the more drastic they will have to be.

"On the basis of existing product prices, the realization of these yields will obviously mean a large reduction in refinery income per barrel of crude run. The increase in the yields of kerosine, and distillate and residual fuel oil and the reduction in gasoline yields called for in the program are set forth for the three districts, in comparison with present operations and those of previous periods, in an accompanying table.

"These adjustments mean in effect that, to accomplish the average yields forecast, about 270,000 barrels daily of gasoline must in effect be degraded to lower valued products, principally residual fuel oil, during the forecast period, as compared with average operations for the year 1941. On the basis of differentials in current ceiling prices in the three districts, this means a reduction

[*Continued on page 127*]

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180° LONG RADIUS RETURN

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REDUCING OUTLET TEE

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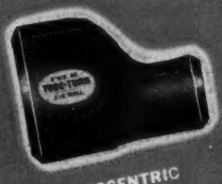
90° SHORT RADIUS ELBOW

45° LONG RADIUS ELBOW

WELDING RING

STRAIGHT LATERAL

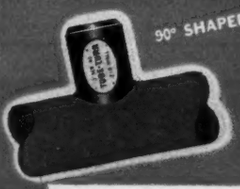


ECCENTRIC REDUCER

CONCENTRIC REDUCER

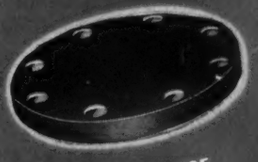
LAP JOINT STUB END

CAP



90° SHAPED NIPPLE

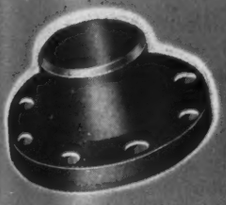
45° SHAPED NIPPLE



BLIND FLANGE

SADDLE

STRAIGHT CROSS



WELDING NECK FLANGE

SLIP-ON FLANGE

LAPPED FLANGE

SCREWED FLANGE

TUBE-TURN WELDING FITTINGS—RANGE OF SIZES

TYPE OF FITTING	DESCRIPTION	STANDARD WEIGHT	EXTRA STRONG	SCHEDULE 160	DOUBLE EXTRA STRONG
ELBOWS	90° LONG RADIUS	½"-24"	¾"-24"	1"-12"	1"-8"
ELBOWS	90° SHORT RADIUS	1"-24"	1½"-24"		
ELBOWS	45° LONG RADIUS	½"-24"	¾"-24"	1"-12"	1"-8"
RETURNS	180° LONG RADIUS	½"-24"	1"-24"	1"-12"	3"-8"
RETURNS	180° SHORT RADIUS	1"-24"	1½"-24"		
RETURNS	180° EXTRA LONG RADIUS	1"-2½"	1"-2½"		
TEES	STRAIGHT	¾"-24"	¾"-24"	1"-12"	1"-8"
TEES	REDUCING OUTLET	¾"-24"	¾"-24"	1"-12"	1"-8"
REDUCERS	Concentric and Eccentric	1x¾"-24x20"	1x¾"-24x20"		1x¾"-12x10*
CAPS		1"-24"	1"-24"		1"-24"
STUB ENDS	LAP JOINT	1"-24"	1"-24"		
NIPPLES	Shaped, 90° or 45° to Header	1¼"-12"	1¼"-12"		
SADDLES		2"-24"			
LATERALS		1¼"-24"	1¼"-24"		
CROSSES		1¼"-24"	1¼"-24"		
RINGS		¾"-12"	1¼"-12"		
		150, 300, 400†, 600 and 900* Lb.		1500 Lb.	2500 Lb.
FLANGES	WELDING NECK	½"-24"		½"-24"	½"-12"
FLANGES	SLIP-ON	½"-24"		½"-12"	½"-12"
FLANGES	LAP JOINT	½"-24"		½"-24"	½"-12"
FLANGES	THREADED	½"-24"		½"-12"	½"-12"
FLANGES	BLIND	½"-24"		½"-24"	½"-12"

† Dimensions on sizes thru 3½" same as for 600 lb. flanges.

* Dimension on sizes thru 2½" same as for 1500 lb. flanges.

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Efficiency—
Get It With Safety

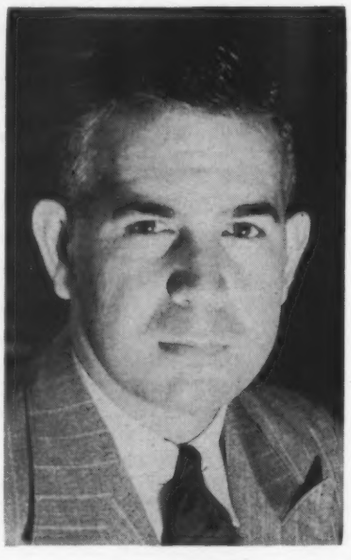
By J. B. HARRIS
Safety Director, Arkansas Natural Gas Corporation

NOT so many years ago when the subject of safety was mentioned around the operating men of the petroleum industry the response was either a derisive sneer, or a careful explanation that "some accidents are bound to happen" and "that's why you carry your insurance." The last few years, even the past few months since Pearl Harbor, have made a drastic change in this conception of safety. Now, instead of being the pet theory of some official of the company or instead of being considered a hindrance to operations, safety is now recognized as a prime factor in improving efficiency throughout the petroleum industry.

Before we go any further, let's stop and look at the record of the petroleum industry safety-wise for the past few years. Let's remember to start with that organized safety work is new in this country, that safety engineering as a profession has come into being in the past quarter century. Until a few years ago the accident rate was extremely high, due to the hazardous conditions under which men were forced to work in the oil industry. As the workmen's-compensation-insurance rates began to mount it became increasingly evident that steps must be taken to improve this condition. Thus, safety was born in the petroleum industry. Curiously enough, when methods were applied to eliminate accidental injuries and when accidents began to decrease, not only the insurance rates began to improve but other costs began to decline proportionately. To be specific it is now an accepted fact that the compensation and medical costs are only one fifth of the total costs incurred by accidental injuries of workers.

But let's turn to the records compiled by the American Petroleum Institute. In 1929 the institute reported 151 fatal accidental injuries out of a total of 226,280 workers, in 1941 although the workers reported had increased to 333,-122 the number of fatalities dropped to 112. During the same period the number of workers to each disabling injury was 15 for 1929 compared to 41 for 1941. In other words, 110 petroleum workers are alive today that would have been killed by accident last year had the same fatal injury rate continued. Moreover, 12,812 disabling injuries were prevented during 1941 by this reduction. A gain in efficiency? The record speaks for itself.

Since the bombing of Pearl Harbor safety has really come into its own throughout all industry in the United States. President Roosevelt, Donald Nelson, Paul McNutt and other leaders have made statements that accidents are sabotaging our war effort. During 1941, for example, approximately 18,000 workers were killed by accident. According to the National Safety Council 460,000,000 man days were lost due to accidents, most of which could have been easily prevented. Transformed into war production these lost man hours would have produced 20 more battleships, 100 more destroyers, 9000 more bombers and 40,000 more tanks.



J. B. HARRIS

Safety director for Arkansas Natural Gas Corporation, Shreveport, Louisiana, after attending Southwestern University and University of Missouri, joined the company in 1936 as junior engineer, advanced to chief clerk of the insurance department in 1937, and has been safety director since November, 1939. He is a member of the executive committee of the Petroleum Section of the National Safety Council, and editor of *Petroleum Safety*, monthly newsletter of the Petroleum Section of the Council.

According to figures just released by the federal government approximately 20,000,000 more persons will be needed by the end of 1943 to augment our war program. This is going to make heavy inroads into the manpower of the nation and increase the value of each skilled worker. It is just common sense then to take steps to protect that valued asset, the trained worker. To accomplish this task an effort will be made to reach every worker throughout the country emphasizing the necessity of working safely for war production.

For instance, one approach to the problem will be something like this: This is going to be a war of production and America needs every man and woman to produce during the next few months, it is an all-out war and we must make an all-out effort. Only sound, healthy workers can produce war goods, the sick, the crippled are just an additional hindrance to this country. Moreover, accidents usually result in damaged tools and equipment; to replace or repair them requires vital material. At the same time our Army and Navy need metal badly; so, in effect, accidents are robbing the soldiers and sailors of guns and tanks and planes. In addition, accidental injuries call for medical equipment and supplies, both of which are needed by our military, thus by preventing injury to ourselves we are conserving badly needed medical supplies for our wounded boys in uniform.

Safety's Three "E's"

Because of its vital part in this war effort, the petroleum industry is going to have an increasingly important part to play in the reduction of accidental injuries among its workers. The figures quoted earlier show that while the industry has decreased its disabling injury rate approximately 65 percent during the past 12 years, it will be called upon to decrease it considerably more during the next few months. Within 12 more years, throughout the industry, the disabling injury will be regarded as an exception rather than the rule by continuing to apply scientific media, known as the three "E's," lost time due to injuries will continue to decline.

Just what are these three "E's" and how does the proper application affect not only accident prevention but gen-

[*Continued on page 124*]

NPA Changes Meeting Place to Pittsburgh

Because hotels in Atlantic City have been taken over for military personnel, National Petroleum Association has transferred its annual meeting to Pittsburgh. All sessions will be held in the William Penn Hotel, September 17 and 18.

Group sessions will be held both days of the meeting with general sessions confined to September 17, the final day of the formal program. There will be a fellowship supper that evening and a breakfast the next morning, when three speakers will be heard.

Group sessions for September 16 will be the ODT Tank Car Service Committee in the morning; the A. P. Lubrication Committee, Western Pennsylvania Refiners Traffic Association, Executive Committee Department of Fire and Accident Prevention will meet in the afternoon. Group meetings for September 17 will be the Department of Traffic and Transportation and the Department of Manufacture.

The general session the afternoon of September 17 will begin with the address of N. H. Weber, president, after which the fortieth anniversary of the association will be outlined by E. M. Lyons, who has been active for many years. Speakers at this program will be Ralph K. Davies, Deputy Petroleum Coordinator for War; Bruce K. Brown, Assistant Deputy Coordinator; Robert T. Collier, director of the marketing division, OPC; Greer W. Orton, director materials division, OPC.

Friday morning speakers at the breakfast will be: General W. B. Pyron, liaison officer for petroleum, War Department; John D. Gill, the Atlantic Refining Company, and chairman of the PIWC committee on impact of the war on the petroleum industry; Hallet Abend, New York Times' Far Eastern Correspondent.

Petroleum Section Safety Program

Meetings of the Petroleum Section of the National Safety Council, in Chicago, October 27, 28 and 29, will be held in the LaSalle Hotel. The program will consist largely of considering problems that have arisen because of the war.

The first session the afternoon of October 27 will consist of reports on activities of the section, an address by some leader from the petroleum industry, a discussion of health as an accident factor and the use of safety methods to reduce absenteeism from illness. Officials for the ensuing year will be elected.

The next afternoon will be devoted to a tour of the Underwriters Laboratories main testing station. Laboratory procedure will be outlined and groups will visit the testing rooms.

The Petroleum Section luncheon will come the third noon. Reports of safety records will be made and contest trophies awarded. This program will be completed by brief discussions from the floor on the general subject, "Current Problems in Petroleum Safety."

The Central Committee on Accident Prevention of the American Petroleum Institute will be in the same hotel, either the day previous or the day following the annual meeting of the petroleum section.

THE LOOK BOX

Safety Congress Dates And Location Changed

Both dates and meeting places of the thirty-first meeting of the National Safety Congress and Exposition have been changed. The sessions will be held in Chicago, October 27, 28 and 29, with the Sherman, LaSalle and Morrison hotels for meeting places. Originally the Stevens and Congress hotels were selected as meeting places.

The changes will not affect the program. There will be 200 sessions with 500 programs participants.

Ned H. Dearborn, New York, has been elected executive vice president and managing director of the National Safety Council. His selection followed the retirement of William H. Cameron, who had been managing director for almost 30 years. Cameron will continue as a member of the executive committee as well as a member of the board of directors.

The new managing director has had wide experience in administrative work as well as accident prevention. Since 1934 he has been dean of the division of general education of New York University, where he set up the Center for Safety Education.

CONVENTIONS

SEPT. 7–11	American Chemical Society, Buffalo, New York.
17–18	National Petroleum Association, William Penn Hotel, Pittsburgh.
OCT. 2	American Institute of Mining and Metallurgical Engineers, Regional Meeting, St. Louis.
9	Western Petroleum Refiners Association, Regional Technical Meeting, Allis Hotel, Wichita, Kansas.
12–14	American Society of Mechanical Engineers, Rochester, New York.
15–16	American Institute of Mining and Metallurgical Engineers, Petroleum Division, Hotel Ambassador, Los Angeles.
22–23	Society of Automotive Engineers, Midwest Fuel and Lubricants Meeting, Tulsa.
25–29	National Lubricating Grease Institute, New Orleans.
27–29	National Safety Congress and Exposition, Hotel Sherman, Chicago.
29–31	American Institute of Mining and Metallurgical Engineers, Petroleum Division, Austin, Texas.
30	Western Petroleum Refiners Association, Regional Technical Meeting, Washington-Youree Hotel, Shreveport.
NOV. 6	California Natural Gasoline Association, Los Angeles.
9–13	American Petroleum Institute, Palmer House, Chicago.
16–18	American Institute of Chemical Engineers, Netherlands Plaza Hotel, Cincinnati.
30	American Society of Mechanical Engineers, Annual Meeting, Through December 4, New York.

More Plants to Make Butadiene

The butadiene program was altered last month to permit more use of existing equipment. This will permit more companies to take part in providing essential petroleum war products and require the services of smaller plants. While the chief objective is butadiene, the program will enlarge the output of 100-octane aviation gasoline materials and increase the output of toluol.

This wider approach to the war-products program brought postponement of the plant of Rubber Synthetics, Inc., Gary, Indiana. This was slated to be a unit for making 100,000 tons of butadiene per year.

Technological development within the refining industry permitted the change in plans. Although participants in the program have not been made public, predictions of its backers were that it would result in butadiene production at the rate of 200,000 tons per year by January 1. With the new plants still in the original program slated for completion during 1943, this early output would give rubber polymerization plants an earlier immediate supply of butadiene as well as provide a larger supply over a longer period. Less steel and lower cost per ton will be involved.

Methods to be adapted to the enlarged program include, thermal cracking of gasoline at higher temperatures; addition of catalytic dehydrogenation units to refining plants and to natural gasoline plants, installation of catalytic-cracking units with thermal units; addition of vapor-phase units to thermal-cracking units.

By charging gasoline to thermal units and cracking at 1300 to 1400° F. with low pressure, a high yield of butane-butylene-butadiene can be had. This combination will then go to a purification unit, where solvent extraction will separate butadiene, leaving butanes and butylenes for alkylation and 100-octane aviation gasoline.

Catalytic cracking, in effect dehydrogenation, will be added to both thermal-cracking plants and natural-gasoline plants. Butanes will be charged to the catalytic units, whose output will go through purification (extraction) to separate butadiene and leave butanes and butylenes for processing by alkylation and polymerization to aviation-gasoline stocks.

Direct production of both butadiene and toluol will come by adding reactor and catalytic unit to either topping or cracking equipment, as well as produce essentials for 100-octane aviation gasoline.

By cracking vapors, converting thermal operation to vapor-phase cracking, butadiene, toluol, butylenes, propylenes and ethylene can be produced in unit and one operation.

The several processes are due for installation at at least 25 existing refining plants. Final decisions will be made by the Office of Petroleum Coordinator for War. Proposals are now being submitted. The processes are well established in refining circles. Their adaptation to butadiene manufacture had not been determined when the synthetic-rubber program became a challenge to industry with the fall of the Dutch East Indies earlier in the year.

In addition to speeding the production of butadiene, the several methods will increase output of other critical pe-

troleum products. In the adaptation of thermal units to the cracking of gasoline at high temperatures, benzene, toluol, xylene, butylene and isobutylene will be produced. Benzine can be further processed to make styrene, second petroleum ingredient for Buna S rubber. Toluol will go into explosive manufacture. Xylene can be used as a solvent or reacted with benzine to make toluol. Normal butylene can be dehydrogenated to butadiene, while isobutylene is an essential for manufacture of Butyl rubber.

Scope of the changed plan, reasons for it and the attitude of the Office of Petroleum Coordinator for War was stated by Bruce K. Brown, deputy coordinator, as follows:

"In view of the great public interest in specific processes sponsored by various individuals and companies, we think it appropriate to state at this time that as we envisage the program it will embody two main types of processes:

"(a) The revision of petroleum-refinery equipment using existing cracking units as nuclei for the production of war products, and other existing refinery equipment as nuclei for the various purification steps involved, and

"(b) The utilization of equipment available in the natural-gas-gasoline industry for the production of war products and for the purification of such war products.

"Catalytic processes for the production of butadiene from butane appear to us to be adaptable to the refinery conversion program," he continued, "and we anticipate receiving and approving proposals of this type as well as proposals involving the conversion of cracking units.

"This office is willing to give informal advice which may be of help in completing proposals and will be glad to receive advance information as to proposals in course of preparation. However, no decision can be reached by this office as to any specific proposal until it is complete and no effort will be made to 'save a place' in the program for any refiner who is delayed, for any reason, in submitting a complete proposal.

"Particular attention is called to the fact that the bottleneck in the refinery-conversion program will probably be the availability of existing equipment to purify the products rather than the availability of equipment to make them. Strenuous technical effort is being expended to attempt to improve the situation with respect to purification of products, including butadiene, benzene and toluene. Proposals relative to the purifiication of products are just as important, perhaps more important at the present time, than are proposals to make such products, and refiners are invited particularly to look into the possibility of entering the program from the standpoint of the purification of products made by others.

"Many of the larger refiners are already busy on plans for the production of war products. While they will be able to contribute to the present refinery-conversion program and perhaps may be able to submit acceptable proposals very rapidly, OPC particularly desires to receive proposals from small refiners."

While each refining concern is expected to select its own process, the Office of the Petroleum Coordinator for War will judge each with especial care on two points, amount of steel required for plant conversion and the minimum amount of war products to be manufactured. Ralph K. Davies, deputy coordinator, outlined this attitude with the following statement:

"In keeping with the well-established policy of this office, we shall expect each participant in the program to make his own selection of the processes he proposes to use. We are prepared, within reasonable limits, to criticize plans which are submitted, and to offer suggestions for improvement; but the fundamental responsibility for the selection of a process must remain with the company submitting the proposal.

"We shall expect each participant to submit his own proposal, bearing in mind that no projects will be approved except those which will use an absolute minimum of anything other than existing equipment.

"It will be the policy of the OPC to give fair treatment to each general type of process, giving consideration to the fact that, regardless of the merit of any specific proposals received from anyone, it will be necessary that we produce certain minimum quantities of each of these essential products as a part of the program.

"Time is precious, and it will, therefore, be the policy of the OPC to recommend, for immediate adoption, such refinery conversion proposals as are received in acceptable form and are found by us to be worthy of such recommendation."

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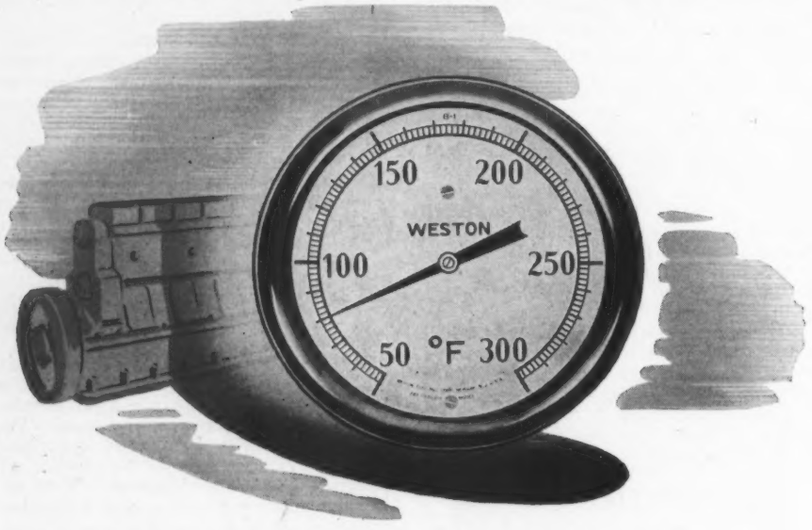

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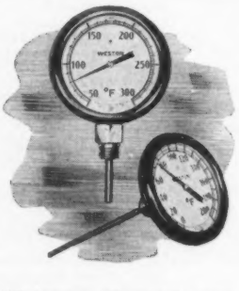

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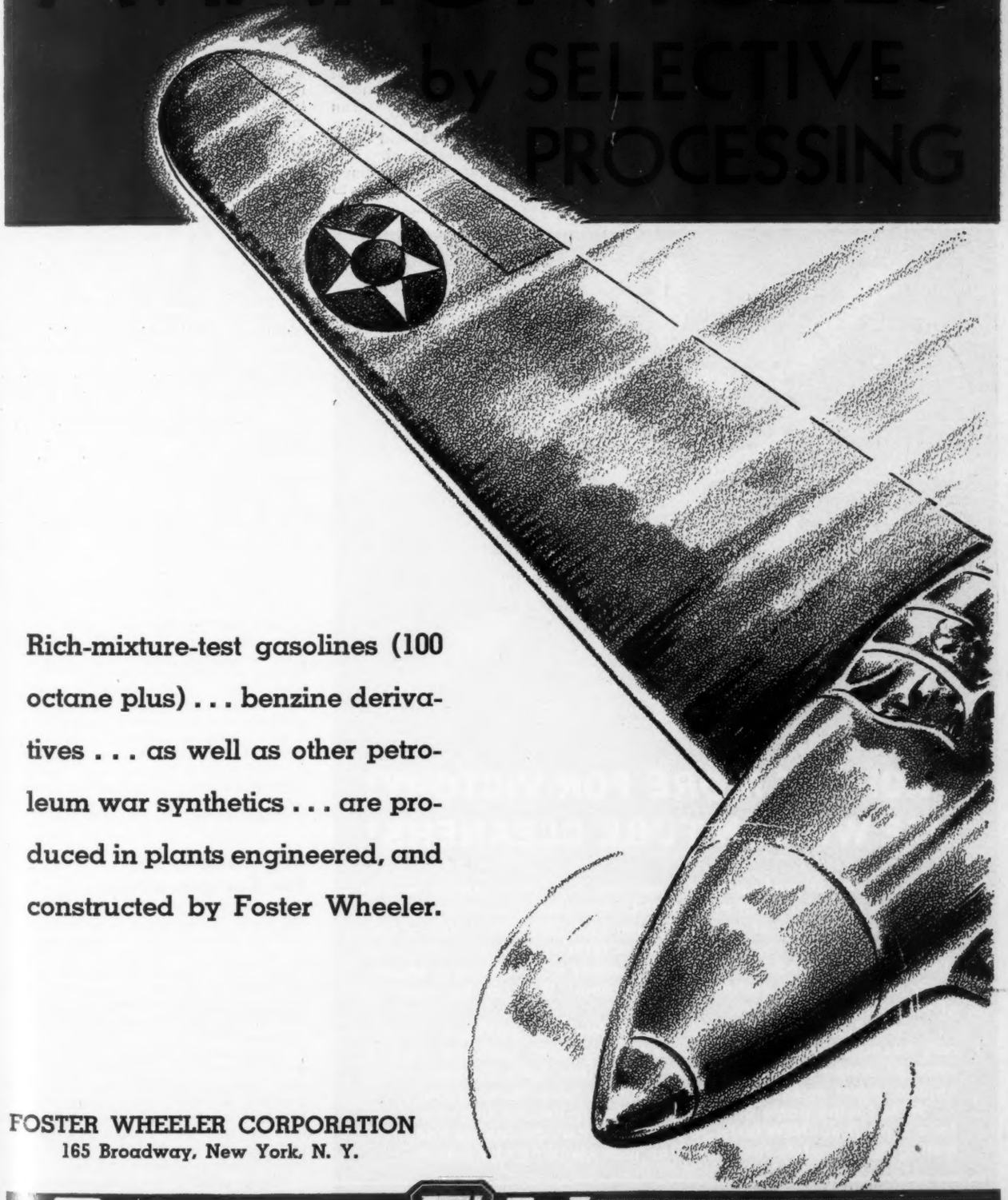

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More Tank Cars to Eastern Service

Use of railway tank cars for hauling automotive gasline in 20 states of the Middle West and Southwest was forbidden by a directive of the Office of Petroleum Coordinator for War August 21. The order provided at least 5000 additional tank cars for service in hauling crude oil and petroleum products to the Atlantic Seaboard. This will place more than 75,000 tank cars in this service

Deliveries of oil to the eastern area had reached 830,000 barrels daily previous to the order.

The directive also made provision for refining concerns to make joint use of transportation, storage and terminal facilities in the area from which tank cars were withdrawn.

In explanation of the order, Ralph K. Davies, deputy coordinator, said:

"With the increased efficiency achieved in the handling of tank-car movements by the railroads and the oil companies, it is now possible to utilize more cars in the Atlantic Coast service. It has been the policy of this office to provide additional tank cars for hauling oil to the East Coast shortage area as rapidly as the railroads and the oil companies could handle them. The number so assigned to the East Coast run has now risen from about 1,000 to a total of approximately 70,000 and more now can be effectively employed.

"Accordingly, the Office of Petroleum Coordinator for War is today acting to withdraw from the Mid-Continent and the Southwest areas a large additional number of tank cars for this East Coast service. This action takes the form of directive No. 57 of the coordinator, ordering the withdrawal from 20 states of the Middle West and Southwest of all tank cars used there in the movement of gasoline and the assignment of this equipment to Atlantic Seaboard movement.

"This means that approximately 5,000 to 7,000 additional cars will be assigned to the East Coast which will bring the total of tank cars in that service to more than 75,000 or almost 70 percent of all the cars in petroleum service in the United States. The railroads and the oil companies feel confident that they will now be able to utilize that number. If experience proves otherwise, the cars can always be returned."

In addition to stopping gasoline movement by rail in the 20 states, Directive 57 provides that, subject to review by the Office of Petroleum Coordinator all suppliers and distributors affected by the withdrawal of these additional tank cars shall make such joint purchases, sales, loans, or exchanges of products, together with appropriate arrangements for joint use of terminals, transportation and distribution facilities, as may be required in order to attain the maximum efficient utilization of all facilities. Of this provision, Davies said:

"This provision, which has the approval of the Department of Justice and the chairman of the War Production Board, makes it possible for the oil companies to obtain greater efficiency in petroleum distribution through joint use of facilities, and will aid them in effecting transportation rearrangements that will offset, at least to a degree, the loss of the tanks cars to Eastern service.

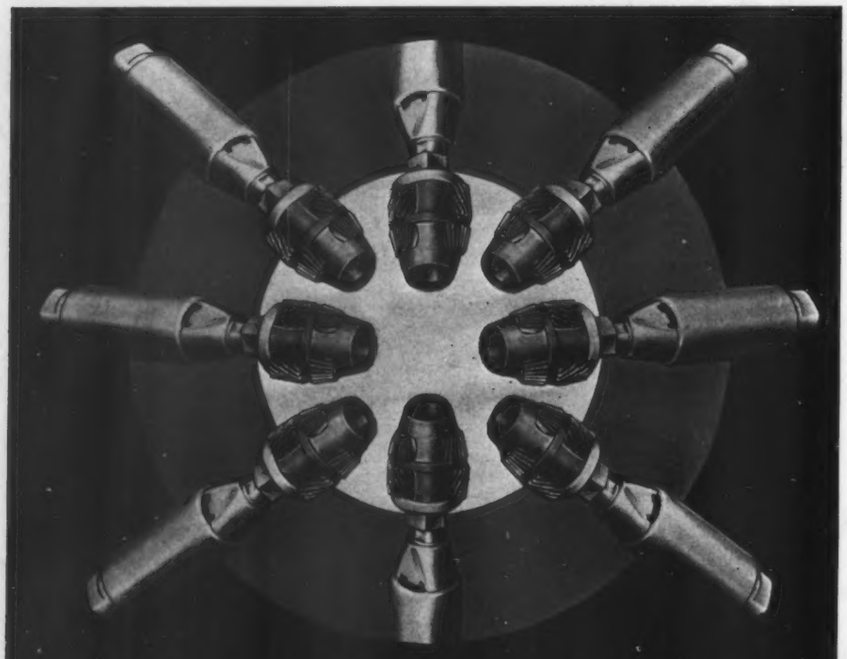
"Whether or not this will be sufficient to permit of the Mid-Continent and Southwest operating without a rationing of petroleum remains to be seen. The Office of Petroleum Coordinator for War has taken the position from the start that transportation should be withdrawn from unrationed areas for the relief of the rationed area as rapidly as it could be usefull employed, and if this withdrawal of transportation created a shortage in the areas losing it, then curtailment should be extended."

Regulations Set For Compensation

Regulations under which the Defense Supplies Corporation will compensate the oil industry for wartime increases in the costs of supplying the Eastern States were issued September 1, with instructions to the companies to file applications for compensatory adjustments with the Reconstruction Finance Corporation's New York office.

Compensation, which is to be paid on imports into the rationed area beginning August 1, will apply to crude, aviation gasoline, all grades of motor gasoline, kerosine, distillate fuel oils and residual fuel oils. Range and stove oil and gas oils are included in the definition of compensable products.

Those eligible for compensatory adjustments will include any person "who produces, manufactures, acquires or purchases crude or compensable products in Districts 2 or 3 and imports the same, by substitute method of transportation, for manufacture or sale within District 1" and in addition, "any



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This is a war of *production* and nothing is more essential to our successful prosecution of the war than a constantly increasing and never failing supply of gasoline, lube and fuel oils, greases, etc. As every *extra hour* that a still or other refinery unit can remain on stream means *increased* production of many vital refinery products, *every minute* of tube cleaning "down-time" that can be saved is of the utmost importance.

Wilson Tube Cleaners clean tubes *faster, better* and *more economically* because they have *extra speed, extra power, extra strength* and *extra all around efficiency*. There is a Wilson Tube Cleaner, cutter head or other accessory for *every* refinery tube cleaning job.

Write for the name of our representative nearest to you or send for a copy of our NEW forty-page catalog fully describing and illustrating the complete line of Wilson tube cleaning equipment.

THOMAS C. WILSON, Inc.
PIPE AND TUBE CLEANERS EXCLUSIVELY
47-28 37th Street Long Island City, N. Y.

DOWTHERM
PROCESS HEATING
ACCEPTANCE

750% increase in 2½ years

For five years Industry tested Dowtherm process heating systems.

The growth was steady — the results excellent.

Then Industry realized — a new method — lower pressure, closer temperature control, better products.

Dowtherm had proved itself!

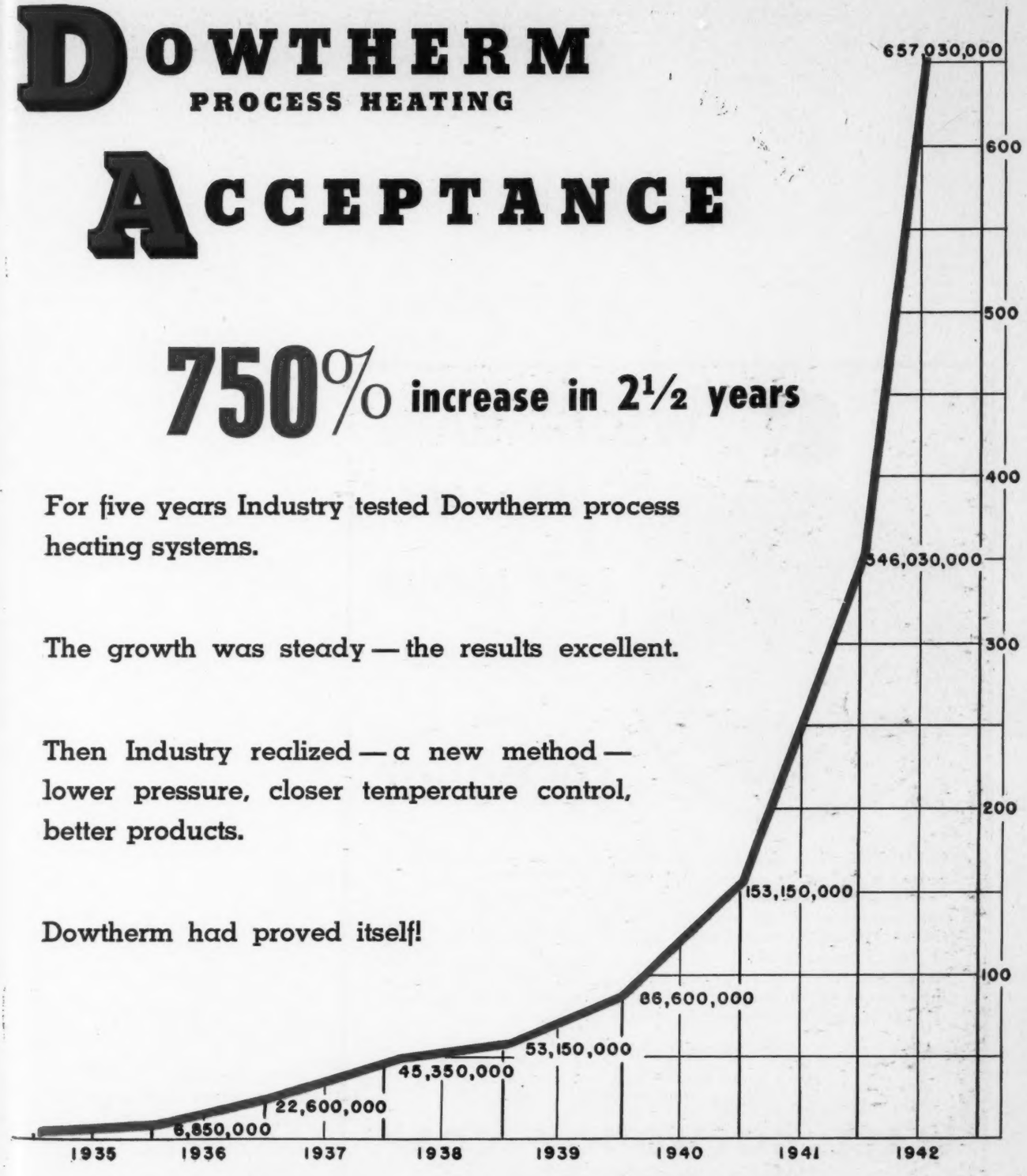


Chart of cumulative capacities of Foster Wheeler Dowtherm vaporizers in millions of B. T. U. per hour.

Foster Wheeler Corporation, 165 Broadway, New York, N. Y.

FOSTER FW WHEELER

person who, during the 12 months' period ending June 30, 1941, regularly imported compensable products for his own consumption within District 1 and who imports, by substitute method of transportation, compensable products from Districts 2 or 3 for his own consumption in District 1 shall likewise be eligible to file an application for a petroleum compensatory adjustment."

To ease the way of the companies, it is provided that as soon as an application is submitted and found to come within the provisions of the regulation and to have been correctly and accurately prepared, an advance payment of 75 percent of the claim will be made, the remainder to be paid following audit.

Extra transportation and product costs are to be computed on the basis of the crude or products actually moved by the substitute method of transportation, which is defined roughly as any method other than the tanker and tanker-and-other-transportation methods which normally would be used.

It is provided that the amount of claim in the case of crude or aviation gasoline imported shall be equal to the excess of (1) the cost of transportation from the actual origin to the destination in District 1 by the substitute method of transportation over (2) the cost of transporting similar products by the facilities which would have been used under the normal method of transportation plus, in the case of crude only, the normal weighted average cost of the pipe-line movement (including gathering charges) of crude from the various fields normally supplying the Gulf Coast area to the tanker, the average to be determined and announced by DSC. In the case of other products, the claim shall be equal to the excess of the value of such products at the actual origin plus the cost of transportation from actual origin to District 1 by the substitute method of transportation over the value and cost of movement by normal facilities.

The compensation will apply to persons who did not participate in the transportation pool, but such claimants shall account for all revenues computed in accordance with the terms of the pool plan as though he had become a member August 1, 1942. Amendments of the plan are under consideration which will permit participation of persons not originally eligible.

The regulation set forth the formula for determining the value of compensable products, other than aviation gasoline, providing that if the actual origin is in District 3 the value at normal origin shall be set forth in a schedule carried in the regulation.

It is also provided that if OPC or ODT direct that in-transit-storage be used in connection with a substitute method of transportation for the purpose of increasing the efficient use of facilities, compensation will be made for the extra costs involved.

WEDGE GATE VALVES LAST LONGER

When Hard Faced with

COLMONOY

COLMONOY alloys offer extreme resistance to galling, corrosion, "wire drawing," and abrasive grit. This unretouched photograph shows a 1/8" cast seat ring of COLMONOY, furnace welded to a wedge gate. COLMONOY greatly increases the life of wedge valves, in spite of high temperatures, extreme pressures and other severe operating conditions.

The exceptionally high wear resistance of the hard surface of COLMONOY alloys will protect all vital wearing parts of your equipment. Mild steel parts coated with COLMONOY alloys wear from 3 to 10 times as long as new parts made of high alloy steel.

WRITE TODAY

Learn about COLMONOY and what it is doing to *conserve vital metals.*

WALL-COLMONOY CORP.

720 Fisher Building, Detroit, Michigan

BRANCH OFFICES
NEW YORK CITY, BLASDELL, N. Y.; CHICAGO; TULSA; WHITTIER, CALIF.
OTHER BRANCHES IN CANADA

COLMONOY

Hard Surfacing Alloys and Overlay Metals

Report May Influence Synthetic Rubber

Influence of the report of the special committee on the whole rubber situation may have some influence on the synthetic rubber program. The committee has completed its work and is ready to report to the President.

The committee, consisting of Bernard M. Baruch, head of the War Industries Board in the first world war; Dr. James B. Conant, president of Harvard University, and Dr. Karl T. Compton, president of Massachusetts Institute of Technology, have been engaged in their studies of the rubber problem for more than a month. The committee was set up by the President when the controversy over the synthetic-rubber program threatened to split the Administration and the problem was taken over by the Chief Executive.

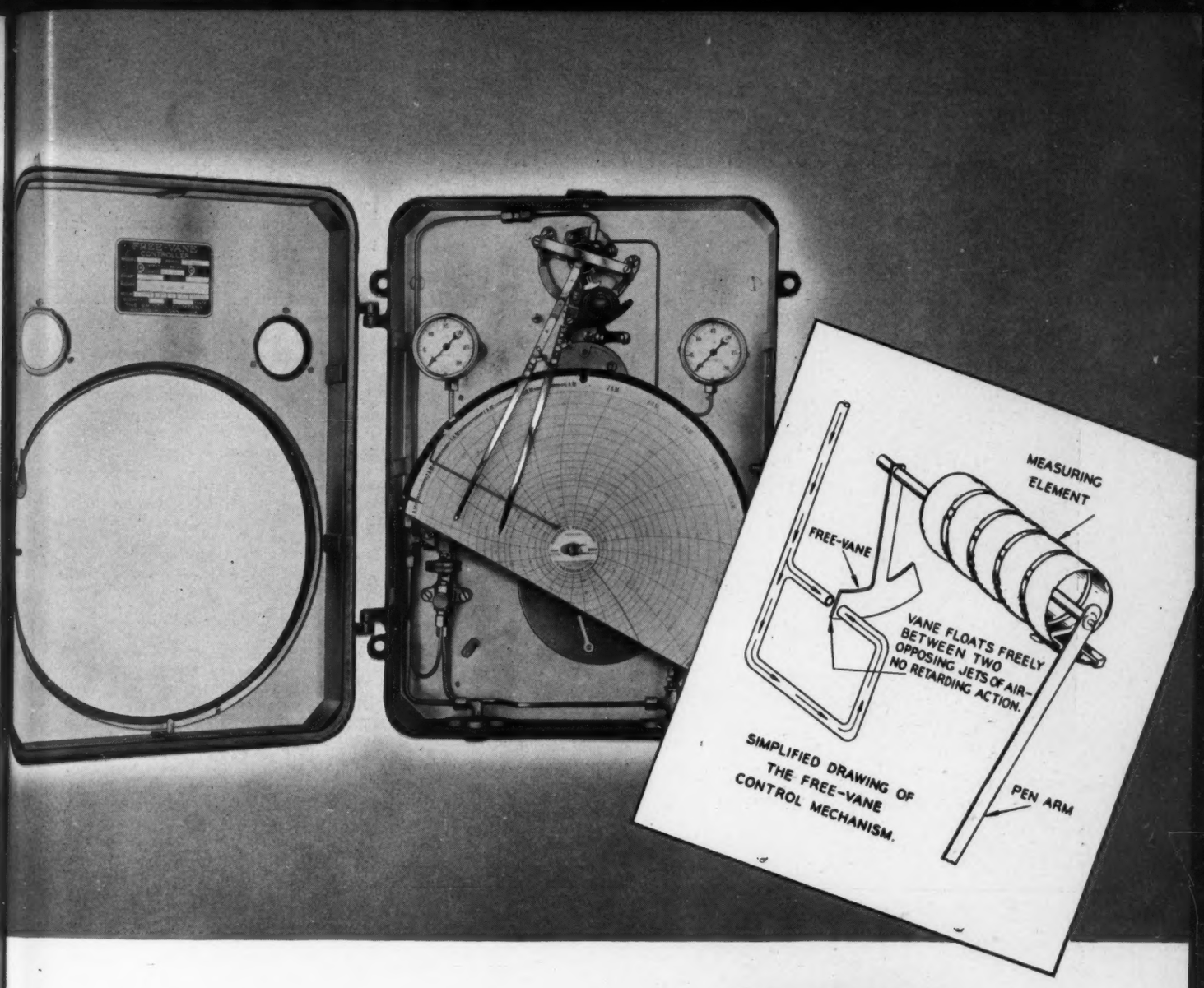
Members of the committee and experts working with them have given no indication of the conclusions they have reached, but it is highly unlikely that the report will please some of the officials and members of Congress who have been quarreling over the rubber situation.

Gary Resigns as OPC Director of Refining

Although Wright W. Gary resigned August 1 as director of refining of the Office of the Petroleum Coordinator for War, he remained in Washington part of the month to assist the staff in furthering the work of converting the refining industry in its intensified drive for the production of critical war materials, especially butadiene.

Directors of Filtrol Corporation, Los Angeles, of which he is now president, have given him the privilege of giving counsel at any time to the refining division of OPC.

His resignation drew many expressions of regret within the petroleum industry, since his department is generally credited with responsibility for bringing the program for the production


MEASURING ELEMENT
FREE-VANE
VANE FLOATS FREELY BETWEEN TWO OPPOSING JETS OF AIR—NO RETARDING ACTION.
SIMPLIFIED DRAWING OF THE FREE-VANE CONTROL MECHANISM.
PEN ARM

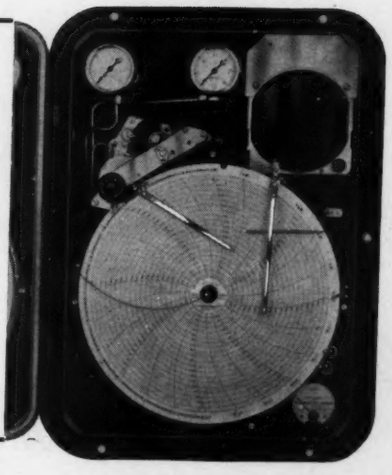
Bristol's Ampliset Free-Vane Pyromaster Controller
Sturdy — Explosion-Resistant — Accurate — Trouble-Free

Combined with the advantages of Bristol's Exclusive Free-Vane System of Control, the Pyromaster shown here, offered as a pyrometer and as a resistance thermometer for controlling temperatures, has the following additional features:

No sparking hazard — all open contacts in heavy sealed case in back of instrument. Pressure switch automatically cuts off supply circuit, if back case is opened. Air control accessibly located at front of instrument;

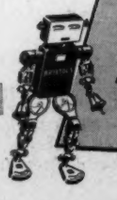
Easy to adjust — throttling range can be changed with a small screw-driver without removing chart or chart dial and without disturbing operation or process;

Never needs oiling or greasing—only 4 units, each easily replaceable, connected only by wire; parts move only when reading changes, minimizing wear.



Send for Bulletin 507 on Pyromaster. Write also for Bulletin 514, describing Bristol's Synchro-Valves — address 111 Bristol Rd., Waterbury, Conn.

Give Better Refinery Control



BRISTOL

AUTOMATIC CONTROLLING AND RECORDING INSTRUMENTS

THE BRISTOL CO. OF CANADA, LTD.
TORONTO, ONTARIO

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WATERBURY, CONNECTICUT

BRISTOL'S INSTRUMENT CO., LTD.
LONDON, N. W. 10, ENGLAND

Resigns as OPC Director of Refining

—Photo Courtesy Office of Petroleum Coordinator

WRIGHT W. GARY

of aviation gasoline into existence ahead of schedule and his efforts in behalf of ingredients for synthetic rubber had progressed in similar relationship.

Coordinator Ickes paid him this compliment:

"Your accomplishment over the difficult year through which we have just lived has been most outstanding and is so recognized, I find, not only within the organization but elsewhere in government circles and in the industry."

His reaction to this praise was tersely expressed, "the credit belongs to the industry. I have never known men so eager to get plants converted to making a needed product. Often this attitude exists when the conversion means monetary loss."

His resignation followed one of his several visits to refining centers, the last one being in behalf of the conversion of existing refining equipment to the production of butadiene. He is convinced that thermal-cracking units can carry much of the burden of butadiene production by adding either catalytic units or vapor-phase thermal units to furnaces now available.

"We have never known how much butadiene we were making, consequently we did not know what existing equipment could do by slight alterations. The industry is now learning and the staff in Washington is capable of giving all necessary assistance," he added.

Gary came to OPC in July 1941, shortly after the agency was set up. His first task was the 100-octane-aviation-gasoline program. While working on that he had to assemble a staff. Although statistics on output of this product have not been made public for several months, it is known that the output of aviation gasoline progressed ahead of schedule.

Gary has been connected with the petroleum refining industry for 21 years. He was educated at the University of Pennsylvania and at Stanford University. He had refining experience with Continental Mexican Refining Company. He joined The M. W. Kellogg Company, New York, in 1929 as director of research and development. Later he became assistant to the president, a post he held for six years.

PALMER

"Red-Reading- Mercury"

THERMOMETERS

To "guess" at the temperature would be fatal. Give your workmen an easy-reading thermometer and eliminate any guess-work and thus save spoilage.

The brilliant RED is so easy to read, at any distance, in all kinds of light.

With scientific annealing and careful testing, PALMER builds a thermometer that you can depend upon and then we give you a bright RED column to make the work easier. A full dollar value for every dollar paid.

(No. 300-D catalog sent promptly)

See page 422 in Refinery Catalog

THE PALMER CO., Mfrs.

Industrial, Laboratory, Dial and Recording Thermometers

2513 Norwood Ave., Cincinnati, (Norwood) Ohio Canadian Plant: King & George Sts., Toronto

See telephone directory for Palmer representative.

Humble Gets First E Within Oil Industry

The Army-Navy Production Award was presented to Humble Oil & Refining Company's Ordnance Works in ceremonies August 21, at Baytown, Texas, marking the first time an oil company has received this distinction. The award was a red and blue flag with a white "E" in the center.

Colonel Herbert R. White, executive assistant to Major General L. H. Campbell, Jr., chief of ordnance, represented Under Secretary of War Robert P. Patterson, and presented the flag to H. C. Wiess, president of the company.

Lieutenant Commander J. R. Alexander, assistant inspector of naval materials, Houston district office, representing Under Secretary of the Navy James V. Forrestal, made the token presentation of "E" pins to H. C. Wiess and to H. G. Bailey, president of the Baytown Employes Federation. A token presentation of the pins was made to

ED INSTALLATION!

Shipped Assembled... Minimum Foundations and Floor Space

TODAY, when speed is the watchword throughout industry, CLARK Gas, Diesel and Steam Driven "Angle" Compressors offer the great advantage of maximum speed of installation. Their compact design permits them to be shipped almost completely assembled, — has reduced more than 50% the size of foundations required, as compared with the older horizontal compressors, — and has greatly reduced area of floor space and size of buildings required. See photos at right.

Economy of money as well as time is also highly important today. It is to be noted that the factors mentioned which save time also involve large money savings.

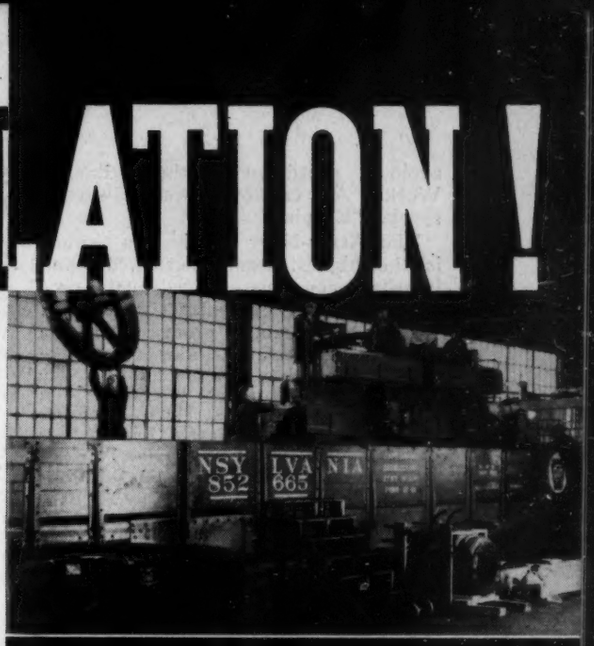
Here are a few of the purposes for which CLARK "Angles" are today in wide demand in the world's industries: Natural Gasoline Recovery, High Octane Gasoline Manufacture, Gas Recycling, Distillate Recovery, Gas Boosting, Oil Refining, Pressure Maintenance, Oil and Gasoline Pipe Line Pumping, Gas Liquefaction, Gas Distribution, Manufacture of Synthetic Ammonia, Synthetic Alcohol, Toluene, Oxygen, Helium, Magnesium, Carbon Dioxide, and other gases and chemicals, Synthetic Rubber Manufacture, Water Flooding, Generator Drive, Refrigeration, Air Compression for glass plants, rock quarries, mines, foundries, machine shops, tank, plane, aluminum and steel plants.

Clark engineers are at your service for consultation and recommendations. Call our nearest office.

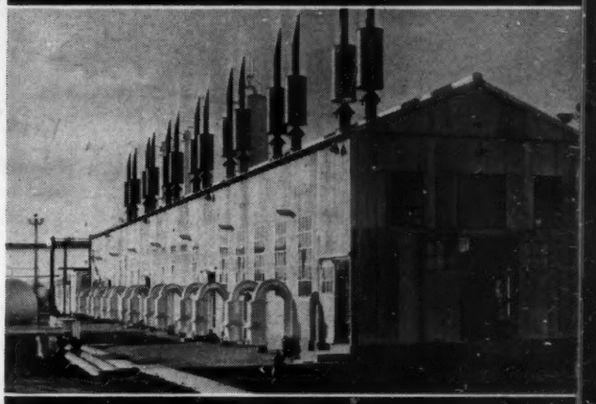
CLARK BROS. CO., INC., Olean, N.Y.
Export offices: 30 Rockefeller Plaza, New York. Domestic Sales Offices and Warehouses: Tulsa, Okla.; Houston, Tex.; Chicago, Ill. (122 S. Michigan Ave.); Boston, Mass. (131 Clarendon St.); Huntington Park, Calif. (5715 Bicket St.); Foreign Offices: 72 Turnmill St., E. C. 1, London; Avda Roque Saenz Pena 832, Buenos Aires.

Affiliated Companies: Dresser Manufacturing Co., Bradford, Pa.; Pacific Pump Works, Huntington Park, Calif.; Bryant Heater Company, Cleveland, Ohio.

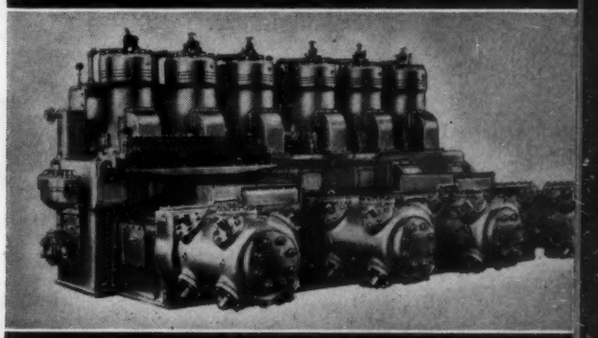
CLARK



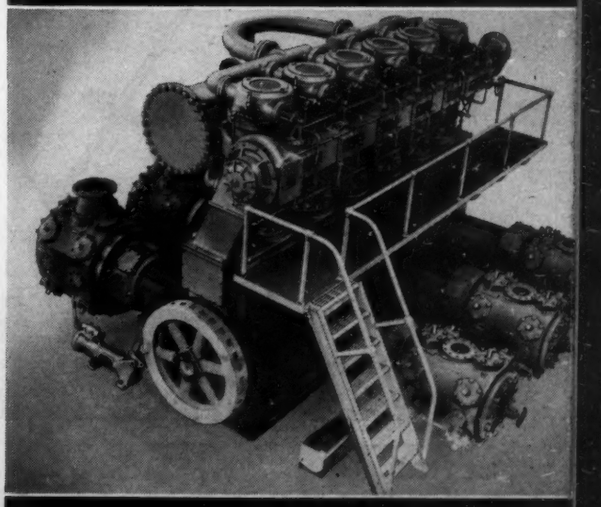
Shipping a CLARK 6-Cylinder Gas-Driven "Angle" fully assembled except for attaching the 4 Compressor Cylinders



This building, only 24 feet wide, houses 7 600 H. P. CLARK "Angle" Compressors, totaling 4,200 H. P.



CLARK 6-Cyl. "Angle" Compressor, gas or Diesel driven. Sizes from 2 to 8 cylinders: Gas-Driven 200 to 1000 H. P.; Diesel Driven, 175 to 700 H. P.



CLARK Model 4 SCRA-14 Steam Engine Driven "Angle" Compressor. Built in 2 to 8-Cyl. Sizes, ranging from 500 to 4,000 H. P.

avoid a shutdown of the Ordnance Works. All employes were awarded special "E" pins.

The Army-Navy Production Award is the highest honor bestowed upon industrial concerns engaged in the production of war equipment or supplies. Quality and quantity production in the light of available facilities are prime factors in selecting recipients for the award. The board which chooses the winners also considers: (1) overcoming of production obstacles, (2) avoidance of stoppages, (3) maintenance of fair labor standards, (4) training of additional labor forces, (5) effective management, (6) records on accidents, health, sanitation, and plant protection and, (7) utilization of sub-contracting facilities.

Scales Promoted by Ethyl Corporation

Richard K. Scales has been appointed assistant director of the technical service department of Ethyl Corporation. In addition to this work with Julian J. Frey, director of the department, Scales will continue in charge of the passenger car and accessory division, with which he has been associated since it was formed.

He entered services of the company in 1929 following his graduation from Cornell University. He worked with Dr. Thomas Midgley in research on compounds used in anti-knock chemicals. After helping to develop a carbon-remover compound he was placed in charge of its manufacture. For three years he represented Ethyl Export Corporation in Australia. He joined the technical service department at Detroit in 1937.

RICHARD K. SCALES

Rationing of Furnace Oil Due October 15

Plans for the rationing of heating oils to domestic consumers beginning October 15 are expected to be announced within the next two weeks, following a decision by the special WPB subcommittee that systematic distribution would be required to spread equitably the reduced supplies of fuel oil in the Eastern States this winter.

Current indications are that the supply will be close to 25 percent under normal, but the actual effect may be somewhat more severe because of the greatly increased population of many of the Eastern war-production areas.

At the White House September 1, President Roosevelt gave his support to the proposal to ration fuel oil, telling his press conference he expected consumption in the East and other areas would have to be cut 25 percent, while Nelson disclosed that consideration is being given to extension of the rationed area to take in the Midwestern States which have been depleted of tank cars.

WPB officials indicated that rationing will go into effect October 15, the opening of the "serious" heating section in the middle and north eastern states.

Maximum temperature in oil-heated Eastern homes next winter may be no higher than 68°—far from comfortable in the damp climate which extends over a large part of the area.

There is no intention in the OPC of easing restrictions on fuel oil and when the present ban on deliveries to consumers expires September 15, there will be a new order, along lines as yet undetermined, to carry through until rationing plans can be put into effect.

Possibilities that the requisitioning of gasoline cars from the Middle West might necessitate delivery curtailment or rationing in some areas were admitted by Ickes, who refused, however, to speculate on when or where such shortages might occur.

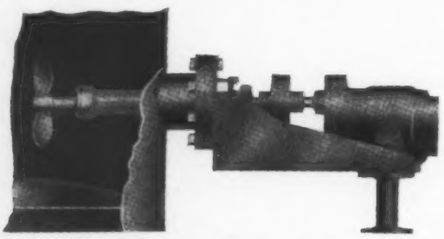
For Quick, Uniform Mixing

Refiners Prefer PORTER EQUIPMENT

● All Porter Equipment is built to give users maximum economy by faster mixing and freedom from breakdowns. Porter Mixers are designed in many types and sizes, to perform efficiently regardless of tank size and shape. Write for complete details and literature.

WHIRLPOOL PORTABLE MIXERS

For quick blending of fuel oils, special oils, etc. Can be moved easily from one tank to another. Geared and ungeared models in all sizes.



SIDE ENTERING MIXERS

For blending and ethylizing gasoline, in large tanks, and for lube blending. All sizes up to 25 H.P.

FLANGE MOUNTED MIXERS

For gasoline and low viscosity oils in small tanks. Geared or direct drive types, in a complete size range.

H. K. PORTER COMPANY, INC.

Process Equipment Division

PITTSBURGH PENNSYLVANIA

New York Chicago

It will open . . . *of course!*

Because it has been folded properly. Because it has been made with care. Because it has been inspected with even greater care.

And because it has been stored in a special air conditioned room—with exact temperature and humidity control—to protect the silk fabric against mildew or other climatic damage.

Ordinary air conditioning . . . the kind of air conditioning you've known in the past . . . wouldn't do for a job like this. *More precise* . . . and *more flexible* equipment . . . the air conditioning of the future . . . had to be developed.

General Electric has been specializing in meeting the difficult air conditioning problems created by America's war effort. Air conditioning to preserve materials . . . to improve the operation of machinery . . . to make it easier for men to work better!

When final Victory is won, many valuable lessons learned in fighting the Battle of Production will be turned to the uses of peace.

More people will be able to enjoy air conditioning in homes, offices and other places . . . because it will be less expensive, more compact. And it will be vastly improved air conditioning . . . with accurate control of *humidity* as well as temperature. *Required climates* will be reproduced at will.

When the time comes to supply the air conditioning needs of the post-war world, General Electric will be ready. General Electric Co., Air Conditioning and Commercial Refrigeration Department, Bloomfield, N.J.

Air Conditioning by

GENERAL ELECTRIC

complete stocks

Vinson CHASE

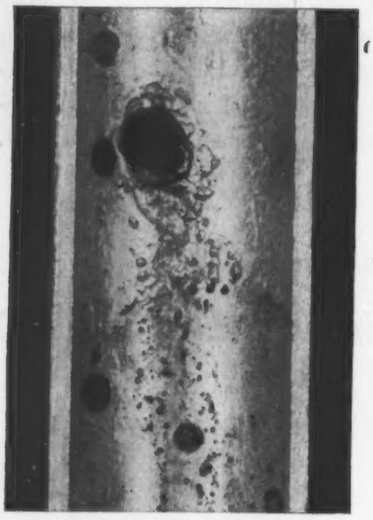
"Antimonial Admiralty" Condenser Tubes

Supply Company

Maintains adequate stocks at central points insuring prompt service, thus complying with the policy of the War Production Board to conserve material through elimination of needless duplication of stocks at individual refineries and gasoline plants.

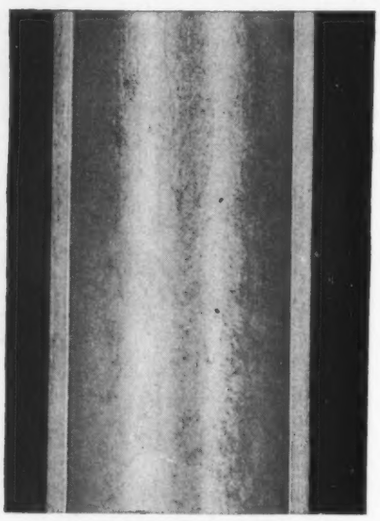
RESIST BOTH DEZINCIFICATION AND SULPHUR CORROSION

Always specify CHASE "Antimonial Admiralty" Condenser Tubes for new Heat Exchangers and Condensers . . . at no extra cost they will insure construction to withstand maximum corrosion.



PLAIN ADMIRALTY

This Tube failed from dezincification.



ANTIMONIAL ADMIRALTY

This Tube still in good condition.

The tubes illustrated above were taken from the same heat exchanger bundle. Both were in service the same length of time.

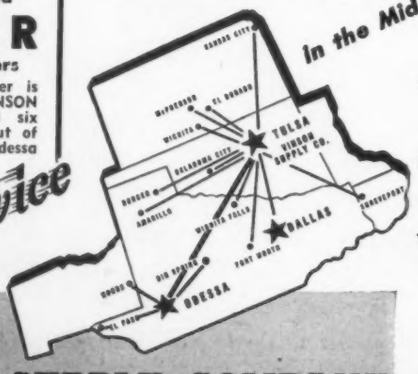
Exclusive Representative Throughout the Mid-Continent Area

FISHER

Automatic Controllers

A Fisher Trained Engineer is always available at VINSON SUPPLY COMPANY and six Fisher Engineers travel out of the Tulsa, Dallas and Odessa offices giving a COMPLETE Sales and Installation Service.

Fast Service



In the Mid-Continent

FISHER
Automatic Controllers

NATIONAL
Pipe and Steel Tubes

TUBE-TURNS
Tees, Reducers, Flanges and Welding Caps

CHASE
"Antimonial Admiralty" Condenser Tubes

Standard Brass Products

VINSON SUPPLY COMPANY

TULSA, DALLAS and ODESSA, TEXAS

Committees Continue Rubber Investigation

Irked over refusal of Secretary of Commerce Jesse H. Jones to permit officials of his Defense Rubber Company to testify regarding the synthetic rubber program, Representative Hartley of New Jersey has asked that official status be given the unofficial House committee under Representative Fitzgerald of Connecticut, which has been investigating the gasoline and rubber situation.

When it attempted to probe into the synthetic rubber situation, however, the committee was defied by Jones, who refused to permit officials to appear for questioning or to answer a lengthy questionnaire which the committee had submitted. To do either, Jones explained, might result in the disclosure of information of military value.

The Senate Agriculture subcommittee which has been making a study of the alleged failure of the Administration to give proper place in the rubber program to production from farm commodities also renewed its activity, with Chairman Gillette of Iowa charging that there had been discrimination in the allocation of materials for rubber plants, which, he declared, should be investigated.

Formal Committee Sought

On September 3, Congressman Hartley introduced a resolution giving the Fitzgerald committee formal status with the power of subpoena to make a thorough investigation of the rubber situation, and in a long outline of the unsuccessful efforts of the group to secure information declared that it has learned enough to indicate that the administration of the gasoline rationing and rubber programs has been "badly bungled."

Hartley spent most of his time in flaying Secretary Jones, who had refused to permit officials of the Rubber Reserve Company to testify before the committee and dismissed the gasoline situation with the comment that "we have had creditable witnesses before our committee who have testified to the fact that the regulations for gasoline rationing were so loosely drawn and have been so laxly administered that there exists today in the Eastern states a black market that is a disgrace.

"For more than a month," he told the House, "the committee has tried to ascertain the exact status of the rubber program for which Congress has appropriated some $650,000,000 and today we know little more, specifically and definitely, about this rubber program than we did more than a month ago when we started out."

Dichlorethyl Ether Under WPB Allocation

Dichlorethyl ether, used principally as a selective solvent for purifying lubrication oils and butadiene, has been placed under complete allocation and use control by orders of the War Production Board.

Effective from September 5, no person may deliver, accept delivery of, or use dichlorethyl ether without specific authorization by the director general for operations. Unlike most allocation orders, which exempt deliveries of small quantities of a controlled material, no exception is made for small quantities.

How Specifying Atmospheric Cooling Towers Speeds War Production

YOU SPEED THE NATION'S WAR EFFORT

BY RELEASING CRITICAL MATERIALS FOR ARMAMENTS

YOU SPEED YOUR PRODUCTION PROGRAM

BY GETTING THREE TIMES FASTER COOLING TOWER DELIVERY

TODAY, the purchaser of a cooling tower, in drawing tower specifications, can base those specifications on conservation of time, materials and man-hours so vital to winning the battle of production, while obtaining highest tower efficiency for the job to be done.

Recently The Fluor Corporation Ltd., manufacturers of both Mechanical Draft Type and Atmospheric Aerator Type cooling towers, completed a survey that compares the amount of time, critical materials and man-hours required for cooling towers of identical capacities of both Atmospheric and Mechanical Draft Types. A copy awaits your request.

The results of this survey show how the specification of Atmospheric Cooling Towers speeds both your war production—and the Nation's. It shows how the delivery time of Atmospheric Cooling Towers is three times faster than other types. It shows how tremendous the savings of critical materials, such as steel and brass, can be in an Atmospheric Cooling Tower. It shows how thousands of man-hours required for the manufacture of towers of Mechanical Draft Types can be diverted to more vital war work by specification of Atmospheric Cooling Towers. It shows how the machine-hours and man-hours going into secondary items, such as fans, gears, switches and motors, required by Mechanical Draft Towers, can be used elsewhere in the war effort because they are not required in an Atmospheric Cooling Tower.

This factual survey takes on added importance when you realize these savings can be made without any sacrifice—for in three cases out of four an Atmospheric Cooling Tower renders service and thermal efficiencies identical with those of Mechanical Draft Towers.

Atmospheric Cooling Towers should be specified except where space or subnormal wind conditions make the use of Mechanical Draft Towers imperative.

Fluor engineers will gladly survey your needs and recommend the proper type tower for your specific needs. Remember, when considering the installation of a cooling tower, a good rule to follow is, *Be Sure With Fluor!*

•

These views show Prefabrication in our Mill and a Portion of Prefabricated Stock ready for shipment from storage.

SINCE 1890

COOLING TOWER DIVISION OF THE FLUOR CORPORATION LTD.

2500 South Atlantic Boulevard, Los Angeles, Calif.

NEW YORK • PITTSBURGH • KANSAS CITY • HOUSTON

FLUOR COOLING TOWERS

ATMOSPHERIC AERATOR AND MECHANICAL DRAFT TYPES

Aromatic Solvents Under Restrictions

Aromatic petroleum solvents other than benzol and toluol will be put under complete allocation October 1, under orders issued by WPB.

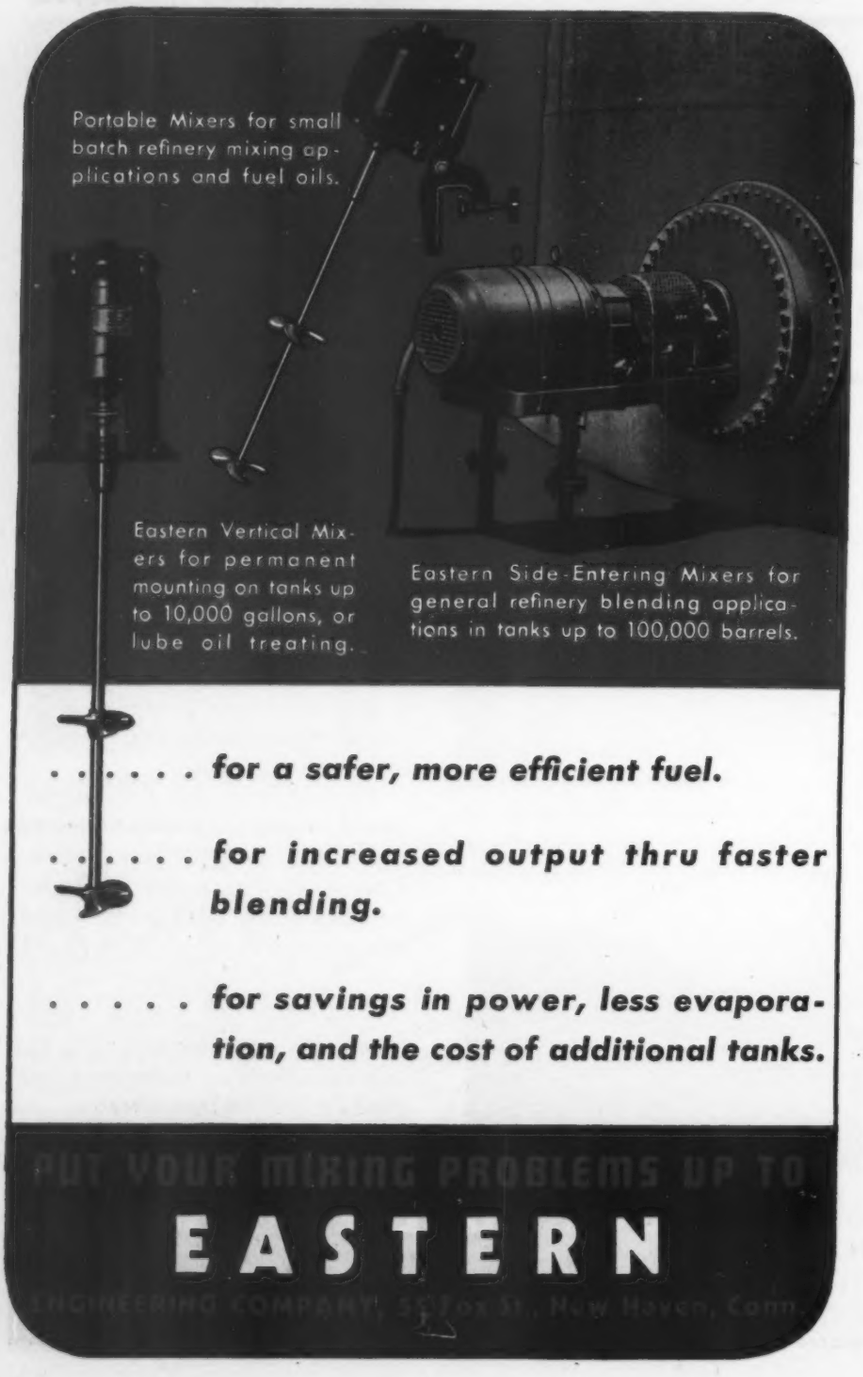
During September, it was ordered, deliveries of aromatic petroleum solvents must be limited to preference ratings of A-2 or higher.

The allocation control will not apply to users requiring 60 gallons or less a month, but for larger quantities applications must be filed on Form PD-600 by the tenth day of the month preceding that for which allocation is requested, and suppliers must report their proposed deliveries by the fifteenth of each month, using Form PD-601.

General License to Restrict Exports

Exports of crude oil and products under general license will be greatly restricted under orders issued by the office of exports of the Board of Economic Warfare, effective September 5.

Whereas, heretofore, BEW has granted general licenses for such exports to a large number of countries in all parts of the world, such licenses hereafter will apply only to shipments to Canada, Great Britain and Northern Ireland, Newfoundland, Greenland, Iceland and Russia and, provided shipments are made overland, Mexico.


Portable Mixers for small batch refinery mixing applications and fuel oils.
Eastern Vertical Mixers for permanent mounting on tanks up to 10,000 gallons, or lube oil treating.
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PUT YOUR MIXING PROBLEMS UP TO
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Safety

[*Continued from page 104*]

eral efficiency as well? Let's all agree to begin with, that safety and good operation are one and the same thing. If a job is properly done it is safely done.

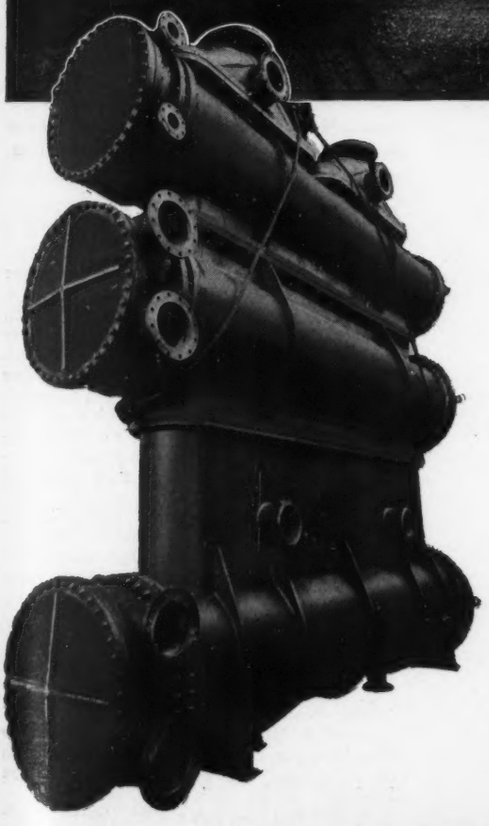
First, there is the "E" known as engineering. This is primarily the managerial responsibility, though in reality responsibility rests with management for all phases of safety activity. Proper application of this measure calls for proper layout, providing adequate safeguards, providing proper safety equipment and generally making the conditions under which the men work as safe as possible. This is the first and a very important step, for unless management shows that it has a genuine interest in the matter and proves it by making the job safe, then the men are not going to take it very seriously.

Second, a mighty important "E" is education. This is sometimes looked on as a long range matter, although oil workers generally have now been sold on the value of safety to themselves and their families. By means of posters, articles in company magazines, movies, safety meetings, letters from the management and other well known devices, the worker is subjected to propaganda on all sides to the effect that the safe way is the proper way to do the job. He must be sold and then resold on the idea that safety helps him earn a living.

Here again the question of the labor shortage crops up. More and more new workers are being hired daily and these workers, untried and unskilled, not only are a hazard to themselves, but to the men with whom they work. This can be solved only by a planned program of training. New men must be instructed by their foremen and shown how to do the job properly. Too much instruction in the past has consisted of merely, "Here it is, now be careful, because we don't want you to get hurt." The new man does not know, therefore he must be taught. The best method of teaching is by explanation, demonstration and performance. Once the man is shown the hazards of his work and how to best avoid them, it is a matter of supervision on the part of the foreman to see that he carries out his instruction.

The final "E" is enforcement. Here again management steps into the picture through the foreman. The chief duty of the foreman is to see that the policies outlined by management are carried out, since safety is a definite policy outlined by management, the foreman must continually check and

DEPENDABLE SERVICE IS BUILT INTO KELLOGG HEAT EXCHANGERS



Verified plant records, covering long periods and involving unusual and severe operating conditions —including wide variations in pressures and temperatures—prove beyond question the efficiency, economy and durability of Kellogg-built heat transfer equipment.

Kellogg-designed and Kellogg-built heat exchanger and condenser equipment is efficient, economical and long lived because Kellogg engineers are thoroughly familiar with the many heat transfer problems encountered in refinery operation.

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see that all three phases, all three "E's" are enforced.

Safety Results

What are some of the results that can be expected from a well planned, properly executed safety program?

First, a marked decrease in costs of accidents. Direct costs such as medical and hospital bills, compensation payments and insurance rates will all be substantially reduced.

Second, reduction of indirect costs of accidents. These include cost of repairing damaged material or replacement of broken tools and equipment, time spent by other workers in assisting the injured man, the time of the foreman and officials in investigating and handling the details of the case. Another important factor is the fact that a marked decrease in production is noticed after a serious accident. All these, while not charged directly to the accident on the books of the company are nevertheless expenses that must be borne by the employer.

Third, improved relations between management and men. Once convinced that the company is seriously sold on prevention of injuries, the men take a real interest in the matter and go at it wholeheartedly. Safety meetings give supervisors and men an opportunity to discuss accident-prevention problems together, and if properly conducted provide an excellent place to improve relations.

Fourth, generally increased efficiency results from this program. This can be expected and can be accomplished. It is only logical that accidents impair the efficiency of a gang or crew and the opposite can be expected when accidents are prevented. Moreover, since accidents are chiefly prevented by carefully planning each job in advance, supervisors and men are improving their working methods. The old theory that safety "slows up the work" has long since been discarded by thinking supervisors. As a matter of fact, although much of the needless haste that cripples men has been eliminated, careful job planning has usually sped up the work.

The railroads of this country learned long ago that instead of slowing down schedules, safety made it possible to speed up train operations. This is just one more example of the fact that safety is good operation.

These three "E's" of safety, engineering, education and enforcement, will tend to grow in importance more and more during the coming months of war. The widespread application of these factors will show marked reduction in disabling and fatal injuries, reduction of accident costs, and on the other hand will increase profit, improve employer-employe relations.

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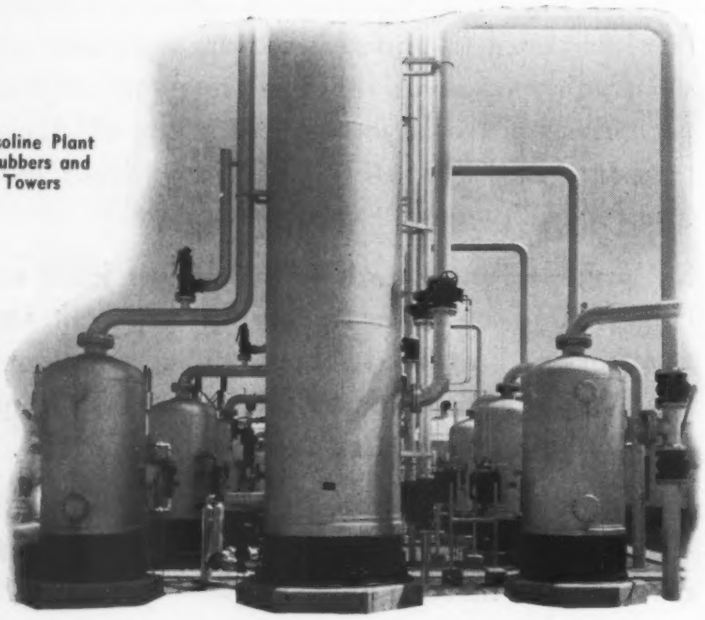

Gasoline Plant Scrubbers and Towers

See COMPOSITE CATALOG Refinery Equipment, Pages 543 to 544.

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Humphreys Promoted By Abasand Oils

C. V. Humphreys, refinery engineer for Abasand Oils, Ltd., since last March, has been promoted to assistant general manager. He will make headquarters in Edmonton.

He started his refinery experience with Standard Oil Company (Indiana) upon leaving college. Later he was with Imperial Oil Company as assistant superintendent at the Imco plant, superintendent of the refining and cracking departments at Sarnia and assistant general superintendent at the Halifax plant. He was on the staff of The W. M. Kellogg Company. From 1932 until 1942 he was in consulting practice at Winnipeg.

J. E. Moorhead Dies in Washington

J. E. Moorhead, executive manager of Pennsylvania Grade Crude Oil Association, Oil City, Pennsylvania, died in Washington August 9, after an illness of two days. He was in the capital on business when stricken.

Moorhead had been with the Pennsylvania organization for the past nine years. Previously he was on the staff of Ohio Petroleum Marketers Association for a brief period. He was advertising manager of Continental Oil Company at Ponca City.

Previous to his connections with the petroleum industry he had been in newspaper work in Colorado and Texas and was secretary to Governor Oliver Shoup of Colorado.

Impact

[Continued from page 102]

in refinery income of approximately $35,000 per day as compared with the income which the refiners would obtain on the hypothesis that they ran the forecast barrels of crude, obtained the average 1941 yields, and sold the products at current ceiling prices. This reduction in gross income would be offset only in small part by reduction in cash operating costs.

"To accomplish the objective will doubtless bring severe hardship to refiners unless the directives for the required yield changes are accompanied by prompt action to compensate for them."

Another high spot of the Council meeting was the discussion of a voluminous report from a committee and subcommittees on the impact of the war on the petroleum industry, which wound up with the report being turned back for revision and resubmission at the October meeting.

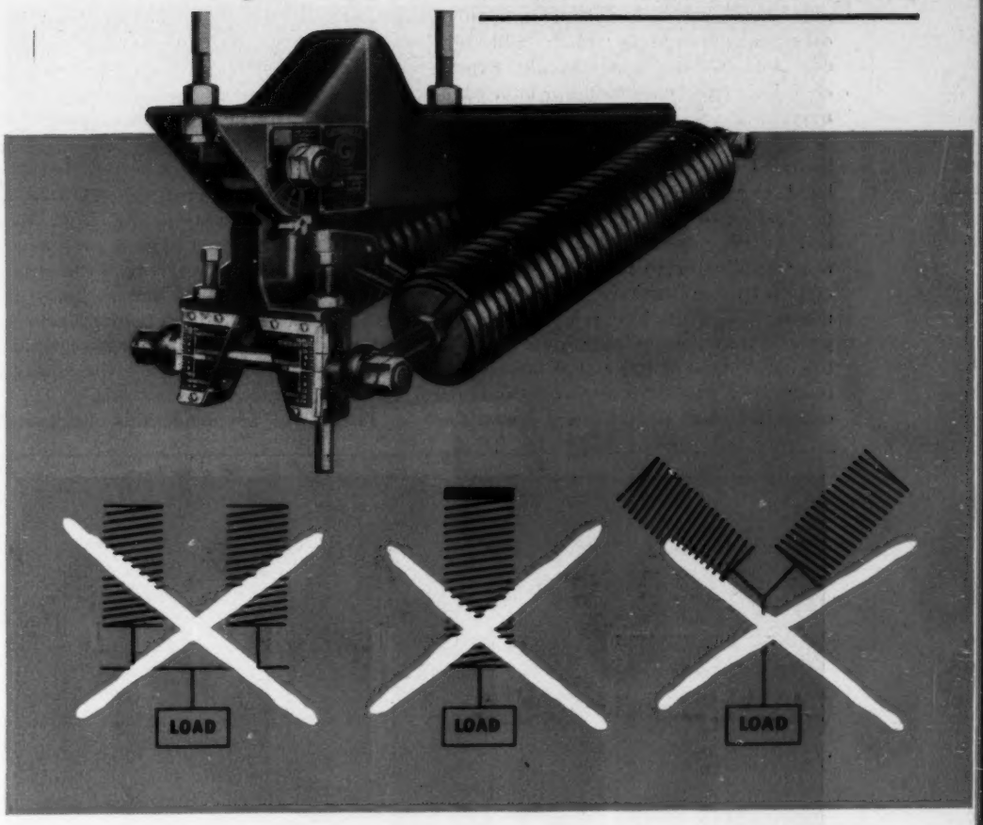
Featuring the impact report was a review of the cost situation arising from changes in refinery procedures, transportation, etc., which it was declared called for government assumption of increased expenses incurred by the industry in conforming to war-agency directives, and the equally imperative need for a definite program of discovery and development to make up the accelerating decrease in reserves.

The council also received a report from its synthetic-rubber committee on progress in the conversion of refinery facilities to the production of "quick" butadiene for rubber, isoprene, ethylbenzene, isobutylene, benzol, toluene and other aromatics.

Details of the status of the plan were not released, but it was indicated by Committee Chairman W. S. S. Rodgers that butadiene production, when and if specific authorizations are obtained from OPC, WPB and Rubber Reserve Company, probably can exceed 200,000 tons annually, and in addition even larger quantities of other materials vitally needed for the war can be obtained. The program, he said, requires relatively little new scarce material, but the plan is so complicated that its exact application to specific refineries has required extensive charting.

The committee also reported progress in the development of a small-scale flexon program, but disclosed that a larger program cannot now be planned because of uncertainties in the supply of isobutylene raw material needed, and also in the demand for isobutylene for other essential war products. However, it was aid, a program has been recommended for manufacture of flexon using a small amount of new materials and

An Important DIFFERENCE



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not interfering with the production of other war products which will give complete, although small-scale, experience that will be valuable in later planning.

Resolutions adopted at the meeting included one requesting OPC to secure legal clearance on a directive holding production of gasoline to 80 percent of last year's output, and another asking the Coordinator to request OPA to reconsider three petitions for price adjustments which it has rejected on the ground that the amounts involved were too small. One of these applications was from the Pacific Northwest and the other two from Mid-Western areas. The amount involved in at least one instance was slightly in excess of $1,000,000 which OPA said was too small, when divided among six or seven companies, to warrant a puncture in the ceiling prices for products.

Also in attendance at one of the sessions were J. R. Sloane of the Office of Defense Transportation, and J. A. McNamara and Robert Capps of the Chemical Division of the War Production Board, who requested the industry to make available at certain points throughout the country, idle oil tankage which could be made available for the storage of alcohol and vegetable oils.

There was a considerable discussion of what has recently become a major subject—the concentration of all authority over oil in the hands of one agency—with many important members of the council emphatic in their declarations that control should be taken from WPB and OPA and placed in the hands of OPC. A number of reasons were advanced for such action, but a major cause of complaint was the alleged lack of coordination of the various federal agencies having an interest in petroleum.

The move to concentrate authority is gaining in Congress, where several measures have been introduced to that end, and Congressmen have taken the matter to the White House, suggesting to President Roosevelt that he bring about the centralization by executive order.

At his press conference, September 3, Coordinator Ickes, asked for his views, pointed out that in the handling of power problems he had always fought for "one-man administration rather than a three-man debating society."

"I never have been very much for shotgun administration," the Coordinator said. "If there's a job to be done, it should be done by one man—I am not saying who it should be, of course."

Cross Licensing Is Authorized

Through a recommendation of the Office of Petroleum Coordinator for War, seven companies, in or affiliated with the petroleum industry, have been authorized to negotiate cross-license and licensing agreements so that the entire oil industry may have available certain efficient methods for producing aviation gasoline, toluene, and other war products with a minimum use of critical materials.

The authorization was granted in a formal recommendation (No. 41 of the Coordinator) signed by Petroleum Coordinator Harold L. Ickes.

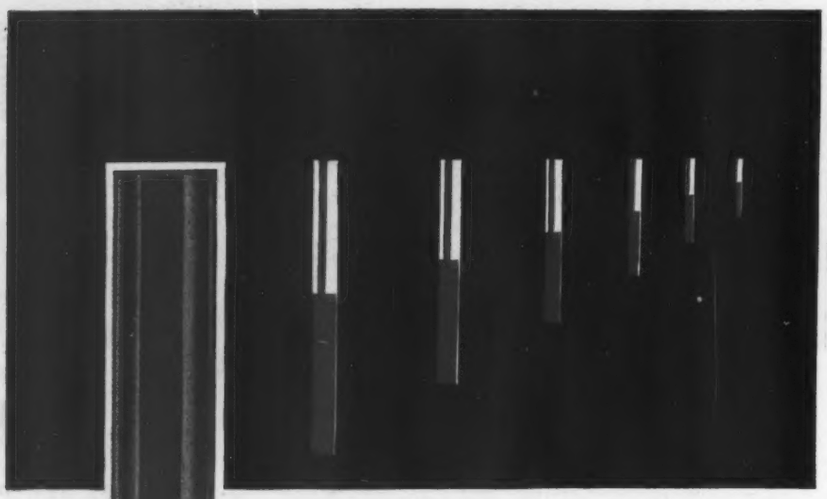
Under the terms of the recommendation, the seven companies are authorized to act jointly in developing processes that will further the production of essential war products.

In making their patented processes available to the entire oil industry, the companies agree to reduce royalty rates materially whenever the processes are used to produce war products.

The recommendation is addressed to the Shell Development Company, Standard Catalytic Company, Standard Oil Development Company, Texaco Development Corporation, Standard Oil Company (Indiana), Universal Oil Products Company, The M. W. Kellogg Company, and their respective affiliated companies.

Cross-license, licensing agreements, royalty rates, and other agreements, cannot become operative until they have been specifically approved by the Office of Petroleum Coordinator for War and certified by the War Production Board.

The recommendation does not affect the provisions of the consent decree entered in the case of the United States versus Standard Oil Company (New Jersey).



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Left, a reproduction from an actual unretouched color photograph which illustrates the appearance of the gauge glass from directly in front.

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Moss Becomes API Consultant on Tankers

James E. Moss, manager of marine operations of The Atlantic Refining Company, has been named full-time consultant of the American Petroleum Institute and will work in cooperation with agencies of government on solution of war tanker and barge problems.

He will serve as the industry's representative to answer and advise on questions of fact, technical problems, and requests for information related to tank ships and barges from governmental agencies. His principal work will be with the Coast Guard, which in addition to its protective functions has taken over most of the duties of the Bureau of Marine Inspection and Navigation, the government office formerly responsible for licensing, tank vessel rules and regulations, etc.

Vice Admiral R. R. Waesche, Commandant of the Coast Guard, in requesting the Institute to designate an industry representative as a consultant, pointed out the numerous unexpected and difficult technical problems in the construction, equipment, maintenance, manning, and other matters affecting the safe operation of tank vessels in war time, and asked that such a consultant be made available to his and other government agencies to aid in the immediate solution of these problems, as well as in the preparation and execution of future plans. Moss also will serve as a member of the panel of consultants of the United States Merchant Marine Council.

SAE Meeting to Study Cargo Airplanes

Preliminary plans for solution of the engineering problems which must precede large-scale development both of wartime transportation of military supplies and personnel and peacetime movement of express and freight cargoes by airplane will be considered at an Air-Cargo Engineering meeting sponsored by the Society of Automotive Engineers December 8 and 9 in the Hotel Knickerbocker, Chicago. The meeting will be held under the auspices of the SAE Chicago Section, with the cooperation of SAE Aircraft and Aircraft-Engine Activities.

The program tentatively calls for discussion of the engineering problems related to current experience in converting passenger airplanes into cargo carriers, design and construction of future "air-freighters," possible utilization of gliders as cargo-carriers, and of engineering factors involved in adapting airport facilities and personnel to demands for expeditious handling of air-cargoes.

Chicago ACS Section Moves Headquarters

The Chicago Section of the American Chemical Society has moved its headquarters to the Medinah Club, 505 North Michigan Avenue. The change was necessary because the former headquarters, the Stevens Hotel, has been taken over by military services.

The Chicago Chemists Club will continue to have headquarters with the Chicago section at the new location, which has facilities for dinners, large gatherings and rooms for group meetings.

Surface waters cascading over rocks and lying quiescent in shaded pools offer an impelling lure to the angler. Even though crystal-clear, however, such water is practically never suitable in its natural state for steam generation, processing or other industrial needs.

Any water from river, deep well or other natural source requires study and treatment before use, to safeguard and prolong the life of boilers and other plant equipment operating under today's heavy demands. The Betz organization of engineers and chemists is trained and skilled in the conditioning of any water for any industrial use. For any plant, however large or small, Betz stands ready to render a complete water service—of consultation, research, design and supervision.

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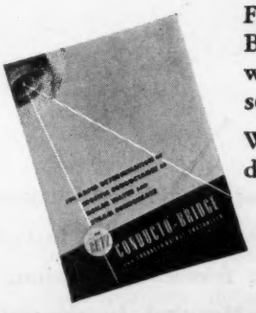

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ABSTRACTS OF PAPERS BEFORE DIVISION OF PETROLEUM CHEMISTRY OF THE AMERICAN CHEMICAL SOCIETY

Buffalo, New York, September 7-11, 1942

Ketones by Condensation of Acid Anhydrides With Olefins, A. C. Byrns and T. F. Doumani, *Union Oil Company of California.*

A synthesis of unsaturated methyl ketones by reaction of branched-chain olefins with acetic anhydride is given. Zinc chloride and sulfuric acid have been found to be effective condensing agents; optimum yields of ketones are obtained with less than one mole of condensing agent per mole of reactants. The methyl octenyl ketone obtained as the principal product from diisobutylene has been shown by ozonolysis to be 4,6,6-trimethyl heptene-3-one-2. Polymer gasoline, obtained from cracking plant gases by polymerization with solid phosphoric acid, has been shown to be a suitable source of olefins. Pilot-plant experiments are reported.

Reduction of Ash Content of Residual Oils With Boric Acid, E. T. Scafe, K. F. Hayden, and V. A. Kalichevsky, *Socony-Vacuum Oil Company.*

A practical method for "de-ashing" residual oils resulting from distillation of crudes in the presence of sodium hydroxide has been developed. The oils are treated with boric acid at about 400° F. and the acid is recovered from the resulting sludge by acidification with sulfuric acid or sulfuric acid sludge. The treated oils are free of moisture and easily pass general specifications developed for industrial fuels.

Phase Equilibria at High Temperatures, Robert R. White and G. G. Brown, *University of Michigan.*

Experimental liquid-vapor phase equilibrium data have been obtained for petroleum fractions boiling from 95° to 750° F. at temperatures from 300° to 820° F. and at pressures from 50 to 700 pounds per square inch. The results have been used to extend the estimated ideal equilibrium vaporization constants to hydrocarbons having boiling points up to 925° F., at temperatures from 0° to 1000° F., and at pressures from 1 atmosphere to 1000 pounds per square inch, and to develop a relationship for estimating the values of the vaporization constants in the critical and retrograde regions of complex hydrocarbon mixtures.

Liquid Capacity of Bubble-Cap Plates, A. J. Good, W. C. Rousseau, and M. H. Hutchinson, *E. B. Badger & Sons Company, Boston, Massachusetts.*

In large diameter bubble-cap towers, or even moderate size towers carrying high liquid loads, the hydraulic gradient set up between upstream and downstream ends of a plate becomes an important factor in determining the maximum liquid load the plate can handle and maintain uniform distribution of vapor over the plate. This gradient has been measured under varying conditions on an experimental plate, and data for one type of bubble cap are given as a function of liquid rate, vapor rate, liquid depth above slots, and certain structural characteristics. Charts can be constructed to enable quick checking of allowable liquid rates.

Catalysis of Lubricating Oil Oxidation, R. G. Larsen and F. A. Armfield, *Shell Development Company, Emeryville, California.*

The catalytic effect of iron, copper, and lead in the bulk and dissolved form on three oils broadly representative of those obtainable from Pennsylvania, Mid-Continent, and California crudes has been studied in detail. The variations in catalytic susceptibilities of the oils, as well as the variations of catalytic activities of the metals with concentration, are so great that it is concluded that no specified catalyst can be used in laboratory oxidation tests unless cor-

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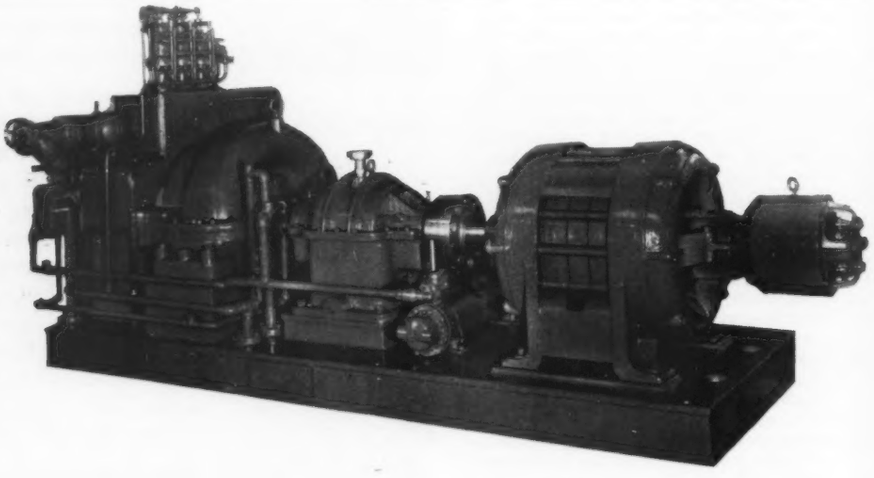

Unit shown is typical of turbo-generators furnished for non-condensing and condensing service in sizes below 500 K.W. Standard equipment includes oil relay governor with multiple valves, trip and throttle valve, forced lubrication, insulation and lagging, etc.

This unit is in operation at a State Hospital in the middle west, is designed for 175 lbs. initial pressure, 5 lbs. exhaust pressure, 4500/1200 RPM.

MURRAY IRON WORKS COMPANY, Burlington, Iowa

respondence with engines is first well established.

In addition, the catalytic effect of engines on oils was investigated. It was found that the oil-insolubles (called crankcase catalysts) which accumulate in engine lubricants are extremely active catalysts. This catalytic activity resides in the metallic constituents, particularly the halides of iron.

Lubricating Oil Detergency, S. K. TALLEY AND R. G. LARSEN, *Shell Development Company, Emeryville, California.*

Four methods of evaluating the detergency of lubricating oils are described. One method involves a chromatographic procedure using lamp black, while the other three make use of centrifugal separation, filtration through an asbestos mat, and infra-red transmission, respectively, to evaluate the degree of dispersion of oil-oxidation products. All show useful correlation, within limits, with engine experience on detergency and, in addition, are useful tools in examining the detergent aspects of lubricating oils.

The Solubility of Hydrogen in n-Butane, E. E. NELSON AND W. S. BONNELL, *Gulf Research and Development Company, Pittsburgh.*

The solubility of hydrogen in *n*-butane was determined at temperatures of 23.9°, 82.2°, and 115.6° C., and at pressures up to 100 atmospheres. At pressures below 30 atmospheres solubility decreases with increase in temperature; from 30 to 40 atmospheres temperature has very little effect on solubility; and above 40 atmospheres solubility increases with increase in temperature over the temperature range investigated. At concentrations of hydrogen above 3 mole percent, the shapes of the P-T bubble-point curves derived from the solubility data suggest the existence of a region of isobaric retrograde condensation at temperatures far below the critical region of the mixtures. Data reported by Kay for the system hydrogen-naphtha show a similar phase behavior, and it is believed that the measurements on hydrogen-*n*-butane constitute additional evidence in support of Kay's suggestion that this may be a characteristic property of a general class of mixtures consisting of a liquid and a slightly soluble gas.

Relation of Refractive Index, Density, and Molecular Weight for All Saturated Hydrocarbons, M. R. LIPKIN AND C. C. MARTIN, *Sun Oil Company Experimental Division, Norwood, Pennsylvania.*

An equation is presented,

$$n = \frac{69.878d - .4044\alpha d - .797\alpha + 136.566}{5.543d - .746\alpha + 126.683}$$

where

n = refractive index at 20° C. for D line of Na,

d = density at 20° C.,

$\alpha = 10^5 \times$ temperature coefficient of density at 20° C., from which it is possible to calculate refractive index (n_D^{20}) within ± 0.001 for all saturated compounds or mixtures of such compounds such as hydrogenated petroleum fractions. The temperature coefficient of density has been shown by Lipkin and Kurtz to be related to molecular weight. It has been possible to calculate the refractive index from density and molecular weight almost within the limits of experimental accuracy. This method of calculating refractive index is more accurate than calculations based on the relationships of Sellmeier-Drude, Eykman, Lorentz-Lorenz, Gladstone and Dale, and is not dependent on a knowledge of structure of the naphthene or paraffin as are the existing equations. The application and significance of this equation will be discussed in subsequent work.

The Ultraviolet Absorption Spectra of a Series of Dienes, EMMA P. CARR AND LUCY W. PICKETT, *Mount Holyoke College, South Hadley, Massachusetts.*

The ultraviolet absorption spectra of 11 aliphatic and 3 cyclic dienes have been examined. These include 10 hydrocarbons, in which the double bonds are conjugated, 2 where they are adjacent, and 2 with isolated double bonds. The characteristic spectra of each type of compound is discussed. The aliphatic dienes show their most characteristic absorption below 2300 A. and microphotometer records of the spectra of eight conjugated dienes in this region are given and discussed in relation to the spectrum of butadiene. These hydrocarbons include 2 pentadienes, 3 hexadienes, and 2 dienes containing 7 and 8 carbon atoms. A brief theoretical interpretation of these spectra is given.

Liquid-Vapor Equilibrium Compositions in the HCl-n-Butane System, J. H. OTTENWELLER, CLARK HOLLOWAY, JR., AND WHITNEY WEINRICH, *Gulf Research and Development Company.*

The compositions of equilibrium

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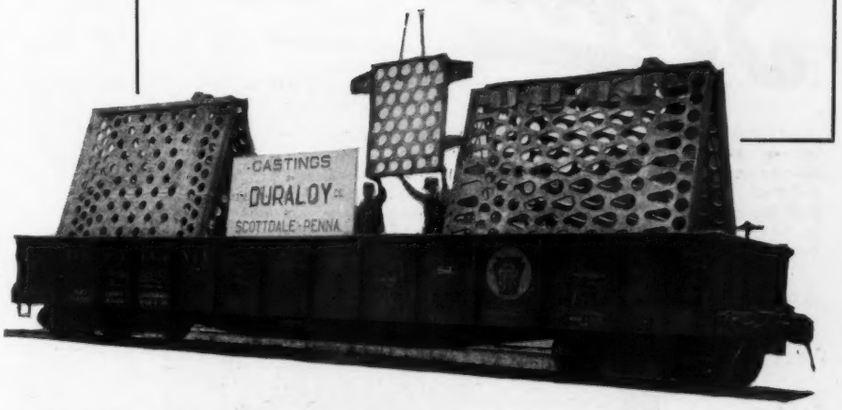

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9-DU-3

vapor-liquid mixtures in the HCl-*n*-butane system were determined at temperatures of 70°, 120°, and 180° F. for pressures below 550 pounds per square inch. The data are presented in tabular form, and also graphically as pressure-composition and as equilibrium constant-pressure diagrams.

The Density and Transition Points of the Straight-Chain Paraffin Hydrocarbons, WM. F. SEYER, RALPH F. PATTERSON, AND JOHN L. KEAYS, *The University of British Columbia, Vancouver, Canada.*

In a previous communication to the Petroleum Division the density and transition points of Diethyl, $C_{32}H_{66}$, were presented. The same investigation has been extended to the even-numbered paraffin hydrocarbons begining at $C_{16}H_{34}$ and up to $C_{34}H_{70}$. The odd-numbered hydrocarbon $C_{29}H_{60}$ has also been studied. The same technique as described in the Journal of the American Chemical Society, 61, 1114 (1939) was used. Most of the hydrocarbons were crystallized 20 times. Melting points could not be given by any single equation. Three equations are necessary of the type log $n-2=a+bt$, from 7-16, 16-33, 33-44 carbon atoms.

$C_{16}H_{34}$ shows no transition points. $C_{18}H_{38}$ to $C_{30}H_{62}$, $C_{32}H_{66}$ show two transition temperatures on cooling but no definite ones on heating. $C_{24}H_{50}$ and $C_{26}H_{54}$ show no transition points on cooling and on heating, but the points on heating depend upon rates of temperature increase.

$C_{28}H_{58}$, $C_{30}H_{62}$, $C_{30}H_{62}$, $C_{32}H_{66}$, $C_{34}H_{70}$, and $C_{29}H_{56}$ all show transition points upon cooling as on heating.

Surface Tensions of Methane-Propane Mixtures, CHARLES F. WEINAUG AND DONALD L. KATZ, *University of Michigan.*

The surface tension of the liquids in equilibrium with vapor have been determined for the methane-propane system over the range of 5° to 194° F. and 40 to 1500 pounds per square inch. The capillary rise and drop volume methods were used in a glass-windowed equilibrium cell. Differences in results between these methods were explained by the high rates of drop formation in the drop volume method.

A formula was developed which reproduces the methane-propane data within 0.1 dyne per cm. This formula may be applied to any mixture when the molecular weight, density, and composition of each phase are known. The research indicated that liquids in the entire critical region have very low surface tensions.

Photoelectric Color. II. A Study of Light-Colored Petroleum Products, J. C. DEAN, R. J. DEGRAY, AND J. W. WILSON, JR., *Socony-Vacuum Oil Company.*

The applicability of photoelectric color for the evaluation of light-colored petroleum products has been demonstrated. Readings are taken with a violet filter and converted to photoelectric color or apparent brilliance by a suitable equation. I.C.I. data may be calculated from photoelectric color readings if desired, although this is usually unnecessary in petroleum technology.

The Saybolt Chromometer has been shown to be unreliable, and to be greatly affected by the surface tension, refractive index, and specific dispersion of the oil being tested. Photoelectric color may be converted to Saybolt color by the establishment of suitable curves for the types of product in question. The colorimeter used is easily standardized and the results obtained are independent of the particular instrument.

Determination of Sucrose, E. P. RITTERSHAUSEN AND R. J. DEGRAY, *Socony-Vacuum Oil Company.*

A method for the control of sucrose used as a tracer in the determination of connate water in drilling mud is described. Sucrose from any other source, and also any material yielding *d*-glucose upon inversion, may be similarly analyzed.

The colorimetric method employs the fact that the inverted sucrose yields a red color when heated with picric acid and sodium carbonate.

All possible variations of the method have been controlled yielding a reproducibility to within 0.13 mg. of sucrose.

Permanent standards may be made with picric acid and methyl orange.

Fanelli Named to Coordinator's Staff

Joseph A. Fanelli, New York, has been appointed special assistant to Ralph K. Davies, deputy petroleum coordinator. He resigned as chairman of the Board of Immigration Appeals, Department of Justice, to accept the new post.

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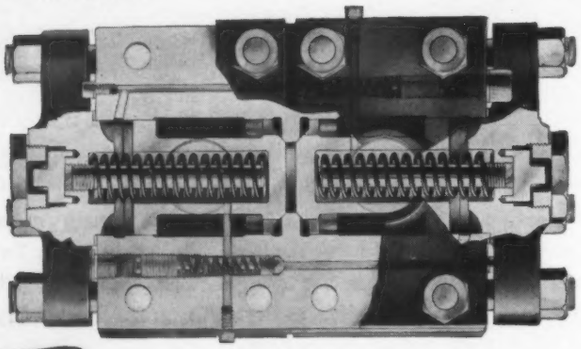

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Exchange of Technical Data Recommended

Exchange of technical information in both processing and operating methods of refining has been recommended to the industry by the Office of Petroleum Coordinator for War. Coordinator Ickes said the exchange would permit speeding up plant construction for critical mateirals as well as save much steel. It is authority to holders of patents to exchange technical information upon recommendation of the coordinator.

When OPC's officials are of the opinion that certain processes or designs controlled by one company can improve the process or plant design used by another manufacturer of an essential petroleum war product, the information will be made available to the second company.

Since speed-up of production is essential, it is also recommended that in event there is a disagreement between companies concerning the detailed arrangement for the use of technical information, litigation must be postponed until the war is ended.

Royalty rates will be subject to the approval of OPC and cannot exceed the rates recommended by OPC.

Further, no license arrangement or exchange agreements will become effective until approved by OPC and WPB.

The recommendation does not affect the provisions of the consent decree entered in the case of the United States versus Standard Oil Company (New Jersey).

"It is anticipated that this recommendation will enable the entire oil industry to operate with maximum efficiency in the production of aviation gasoline, alcohols, benzene, toluene and other materials necessary or useful in prosecution of the war," Ickes said.

Isomerization of Pure Hydrocarbons

This book by Gustav Egloff, George Hulla and V. I. Komarewsky, is one of the monograph series of the American Chemical Society, published by Reinhold Publishing Company, price $9.00.

It is restricted to a consideration of the alkanes with hydrocarbons as both the starting product and the finished material. Its scope is thus outlined in this paragraph from the introduction:

"Isomerization is a shift in the configuration of a molecule, without change in the number of atoms present. The formation of isomers from hydrocarbons by isomerization involves: transformaitons involving single, double or triple bonds; migrations of the aliphatic, alicyclic or aromatic groups; and migration or transfer of hydrogen in the molecule. There are three main classes or hydrocarbon isomerization: structural, geometrical and optical."

The work is a timely addition to the literature because of the part isomerization is playing in providing material for 100-octane aviation gasoline as well as its possibilities in other refinery processing of critical products.

It can be had through the book department of the Gulf Publishing Company, P. O. Box 2608, Houston, Texas.

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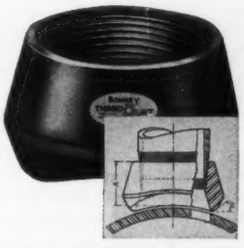

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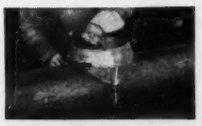

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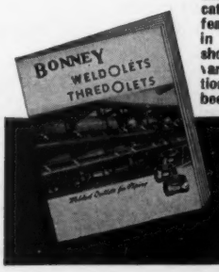

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The abstracts here presented are selected from the current literature of science and technology to afford reference to fundamental information not easily available to all readers. Abstracts of articles appearing in readily obtainable trade journals are not included.

Photostat copies of original articles will be supplied at cost by the Leslie Laboratories. Complete or limited bibliographies covering special topics by title, by abstracts, or in complete manuscript, will also be prepared and furnished at reasonable cost by the Laboratories.

Fundamental Physical and Chemical Data

Equations for the Specific Heats of Gases, J. C. SMALLWOOD, *Ind. & Eng. Chem.* **34** (1942) pp. 863-4.

The purpose of the paper is to present condensed equations for the specific heats of the gases entering the combustion of fuels and contained in the products of combustion. The author notes that the earlier works on specific heat of gases were based upon determination by calorimetric methods or by the indirect method of sound velocity measurements. Since 1930 several researches have been made, based upon quantum theory and spectroscopic observations. The literature of the subject is briefly reviewed. A combined equation is presented that can be used to represent any of the five gases or a mixture of them. Using the combined equation the enthalpy change between any two temperature limits, T_1 and T_2, can be found by multiplying this equation by dT and integrating between the temperature limits.

Molecular Volume Nomograph for Liquid Alkanes, D. S. DAVIS, *Ind. & Eng. Chem.* **34** (1942) p. 797.

A nomograph is presented for determining the molecular volume of the normal liquid paraffin hydrocarbons from methane to octane. The equations on which the nomograph is based are given. Use of the nomograph is illustrated by the solution of a typical example.

P-V-T-x Relations of the System Propane-Isopentane, W. E. VAUGHAN AND F. C. COLLINS, *Ind. & Eng. Chem.* **34** (1942) pp. 885-90.

The study of the phase behavior of pure hydrocarbons and their mixtures has been greatly extended recently, as a result of the increasing importance of such data to the field production and and refinery engineers. The investigation reported included measurement of the P-V-T relations for five different mixtures of propane and isopentane in the temperature range from 0° to 300° C. and in the pressure range from 2 to 80 atmospheres. The primary data comprise pressure-volume relations measured isothermally at 25° intervals. Supplementing these are data obtained to define more clearly the critical region. The data are presented in some detail in four tables and five charts. The data have been used to calculate the phase equilibrium constants.

Phase Equilibria in Hydrocarbon Systems, R. A. BUDENHOLZER, D. F. BOTKIN, B. H. SAGE AND W. N. LACEY, *Ind. & Eng. Chem.* **34** (1942) pp. 878-82.

Joule-Thomson coefficients of three mixtures of methane and propane were determined experimentally at pressures up to 1500 pounds per square inch in the temperature interval between 70° and 310° F. From these experimental data and published heat capacity values for the components at infinite volume, the isothermal enthalpy-pressure coefficients were calculated. From these derived values the partial enthalpies of methane and propane in mixtures of the two substances were established. The results are presented in considerable detail in three tables and five figures.

Critical States of Two-Component Paraffin Systems, F. D. MAYFIELD, *Ind. & Eng. Chem.* **34** (1942) pp. 843-49.

The paper presents empirical correlations by means of which the critical states of two-component normal paraffin hydrocarbon systems can be predicted. Values calculated by means of these correlations are compared with existing published data on ten systems. Disregarding positive and negative signs for the errors, and excluding two systems, the average error for the calculated pressures is 13 pounds per square inch or 1.3 percent, and the average error for the calculated temperatures is 6.4° F. The systems considered in the study were: methane-propane, methane-n-butane, methane-n-pentane, methane-n-hexane, ethane-n-butane, ethane-n-heptane, propane-n-butane, propane-n-pentane, n-butane-n-heptane, n-pentane-n-heptane.

The Variation of Viscosity of Liquids with Temperature, M. K. SRINIVASAN AND B. PRASAD, *Phil. Mag.* **33** (1942) pp. 258-71.

Various equations that have been proposed for connecting viscosity and temperature were examined, including those by Andrade, Macleod, Madge, Silverman, and Irany. They were studied in their application to a number of liquids, including ethylene bromide, ethylene chloride, carbon tetrachloride, isobutyl-bromide, isobutyl iodide, propylene bromide, acetic anhydride, propyl ether, octane, benzene, water, ethyl alcohol, propyl alcohol, and liquid sodium, potassium, galium, and tin. Andrade's modified and unmodified equations are equally accurate. Only one of the equations of Macleod holds for the fused metals. Silverman's simple equation that requires a knowledge of the density gives good results, but his modified equation leads to the erroneous conclusion that the compressibility often decreases with temperature. Madge's equation gives good results but with fused metals requires the assumption that the modulus of elasticity increases with temperature, which is theoretically unsound. Irany's viscosity function is not linear with fused metals. The simple equations of Andrade and Silverman serve equally well but the former is preferred because it requires no knowledge of the density. Andrade's simple formula is the simplest function available and is no less accurate than the other more complex expressions. All of this applies to liquids that are unassociated. Where there is rapid change in the association of liquids with temperature the Andrade formula cannot be expected to hold.

The Carbon-Hydrogen Bond Strengths in Methane and Ethane, H. G. ANDERSEN, C. B. KISTIAKOWSKY AND E. R. VAN ARTSDALEN, *J. Chem. Phys.* **10** (1942) p. 305.

The authors calculated the upper limits of the binding energies to be as follows: ME — H, $102 \equiv 1$ kg.-cal.; Et — H, 98 ± 2 kg.-cal.

Specific Dispersion of Pure Hydrocarbons, R. E. THORPE AND R. G. LARSEN, *Ind. & Eng. Chem.* **34** (1942) pp. 853-63.

Recent activity in the study of hydrocarbons has led to the need for physical constants that can be used not only as a criterion of purity, but also as an indication of structure. One of the obvious advantages of dispersion is that it is a differential value and independent of errors in absolute units of calibration. Also for reasonable ranges of tempera-

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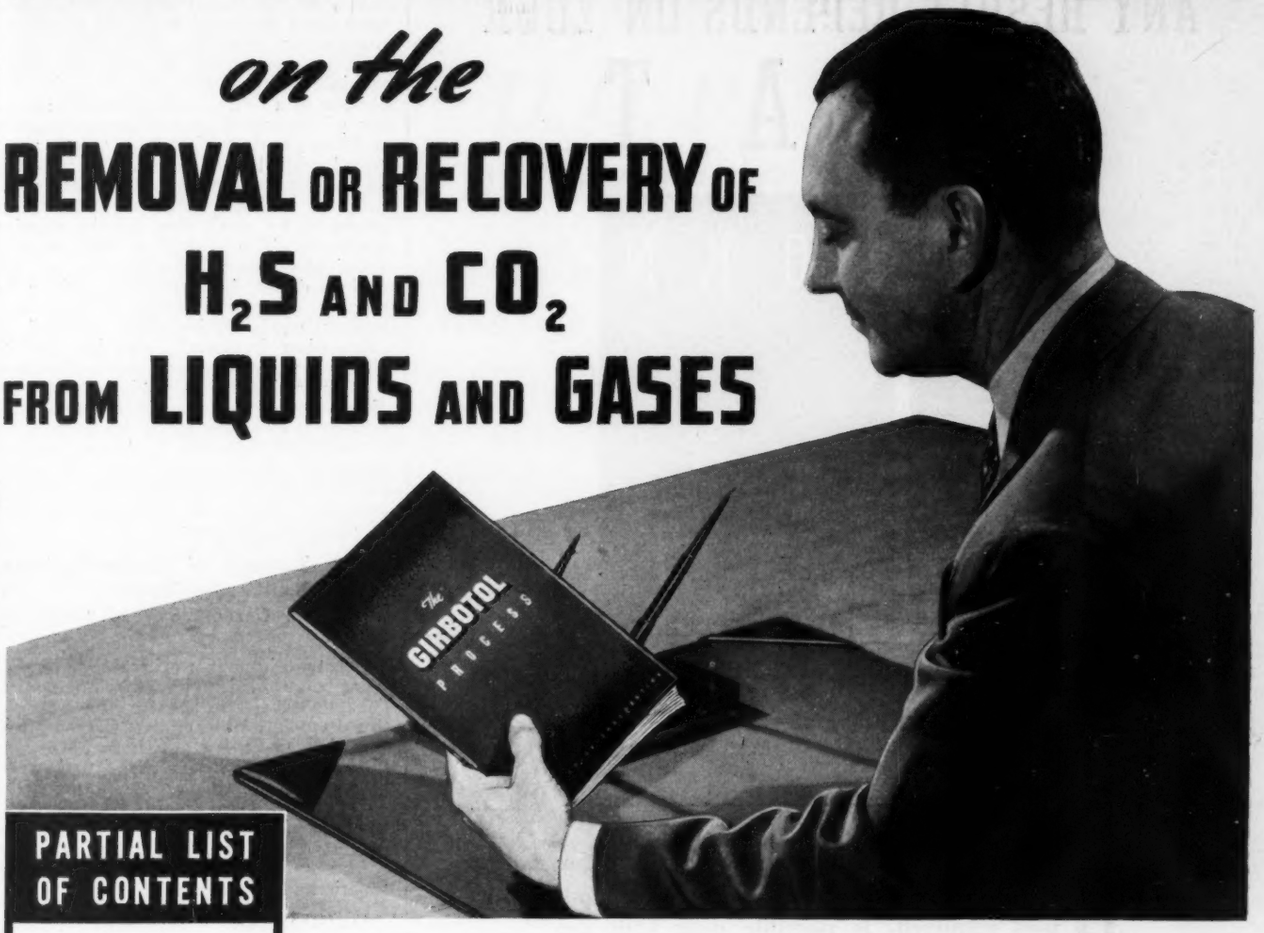

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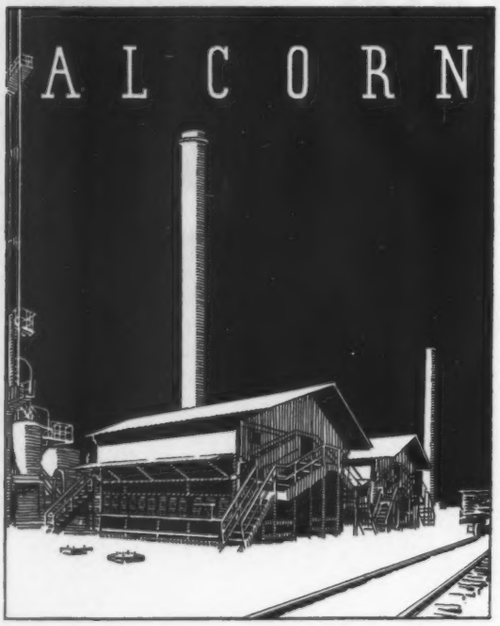

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ture it is essentially independent of temperature. Specific dispersions for a large number and a wide variety of pure hydrocarbons, obtained from the literature and from additional experimental data, have been analyzed with the object of correlating specific dispersion with molecular structure. It has been found possible to calculate the specific dispersion of a hydrocarbon from the number of saturated carbon atoms present and the number of carbon atoms associated with double bonds. The presence of conjugation of the sort that is not confined within a single ring invariably produces an exaltation of the specific dispersion. The exaltation effect may be anticipated by a consideration of the various double bond formulas. Since the specific dispersion depends upon molecular configuration, the method of calculation frequently can be used to obtain information concerning structure. Tables are included showing the specific dispersion of nonconjugated olefins, of nonaromatic conjugated hydrocarbons, of complex benzene hydrocarbons, of saturated alkyl aromatics, of hydrocarbons showing secondary conjugation, of aromatic-naphthenic hydrocarbons, and of phenyl-butadienes.

The Strength of Carbon-Hydrogen and Carbon-Carbon Bonds, D. P. STEVENSON, *J. Chem. Phys.* **10** (1942) pp. 291-4.

Electron-impact critical potentials were combined with thermochemical data to obtain values for the heats of the dissociation reactions, $CH_4 = Me + H$, $C_2H_6 = Et + H$, $C_2H_6 = 2Me$, and $C_4H_{10} = 2ET$. The values found were: $D(Me - H) = 101$ kg.-cal./mole, $D(Et - H) = 96$ kg.-cal./mole, $D(Me - ME) = 82.6$ kg.-cal./mole and $D(Et - Et) = 77.6$ kg.-cal./mole. The values so found were compared with estimates based on kinetic and photochemical data.

Radiant Heat Transmission from Water Vapor, H. C. HOTTEL AND R. B. EGBERT, *Trans. Amer. Inst. Chem. Engrs.* **38** (1942) pp. 531-68.

Allowance for the contribution of infra-red gas radiation to the transmission of heat from flue gases has been based to an increasing extent, during the past decade, on direct laboratory measurements of the total radiation from the gases, carbon dioxide and water vapor. The purpose of the investigation reported was to secure extensive new data on water vapor radiation and to use both the new data and that of previous investigators in the development of a recommended procedure for engineering use. The experiment covered the determination of total radiation from gas columns varying in length from 0.06 feet to 13.33 feet, in temperature from 70° F. to 1300° F., and in partial pressure of water vapor from 0.005 atmospheres to 1.0 atmospheres. A critical analysis of the data of other investigators was made, and all data that did not appear to have large experimental error inherent in them were used along with the experimental results obtained in the present investigation to arrive at a final correlation. The basic chart presented is one that gives the emissivity as a function of gas temperature and the product term (partial pressure of water vapor) $\times$ (beam length), for water vapor in an "ideal" state of zero partial pressure. A second chart allows for the effect of the finite value

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of partial pressure on emissivity. The results indicate that any of the previous recommended correlations could lead to considerable error when extrapolated into ranges not covered by experiment.

Hydrocarbon-Water Solubilities at Elevated Temperatures and Pressures, J. Griswold and J. E. Kasch, *Ind. & Eng. Chem.* **34** (1942) pp. 804-6.

Open steam is used in many petroleum refinery operations, and gasoline or heavy oil are frequently condensed together with steam. The literature discloses many water solubility determinations at temperatures up to 100° C. and at atmospheric pressure. No data have been available for the solubilities of water in hydrocarbons at elevated temperatures and pressures. The article presents experimental data enabling a fairly accurate prediction of the amount of water remaining in oil as a result of refinery operations involving direct contact with steam. Solubilities of water in three petroleum fractions were determined up to 280° C. and 940 pounds pressure. The results indicate that the solubility of water in straight-run petroleum fractions is substantially independent of the molecular weight of the oil. This observation permits a correlation of water dissolved in petroleum fractions in terms of steam pressure and temperature. At any given temperature and pressure, the solubility of water in oil is much greater than that of oil in water, both being expressed on a molar basis. In both phases the solubility of aromatic hydrocarbons with water is several times greater than the solubility of petroleum fractions with water.

The Solubility of Propylene Vapor in Water as Affected by Typical Detergents, J. W. McBain and A. M. Soldate, *Jour. Amer. Chem. Soc.* **64** (1942) pp. 1556-7.

It was previously shown that potassium oleate added to water greatly increased the amount of hydrocarbon dissolved. The solubilized hydrocarbon is incorporated in or upon the colloidal particles or micelles of the soap, thus lowering the vapor pressure of the hydrocarbon and leaving the freezing point of the soap solution unaffected. The investigation reported in the present article was extended to cover a series of typical detergents, surface active agents, and other substances in order to determine whether such solubilization always occurs with detergents, and whether it is in contrast to the effect of salts and mixed solvents. It was found that all detergents tested greatly increase the solubility of propylene in water, whereas salts such as a carbonate, pyrophosphate, or hexametaphosphate, do not.

Chemical Compositions And Reactions

Ionization and Dissociation by Electron Impact: Normal Butane, Isobutane and Ethane, D. P. Stevenson and J. A. Hipple, Jr., *Jour. Amer. Chem. Soc.* **64** (1942) pp. 1588-94.

Mass spectrometer studies of the dissociation products resulting from electron bombardment of the lower hydrocarbons, methane, ethane, ethylene, propane, propylene and allene, have yielded many data on the energies and unimolecular reactions of the ions CH_4+, C_2H_6+, not obtainable in any other way. The authors have extended such studies to one of the simplest isomeric pairs, n- and i-butane. The variation of the relative abundances of the ionic dissociation products formed by electron impact in ethane, normal and isobutane are reported as a function of the energy of the bombarding electrons. The critical potentials of several of the processes have been measured, and their significance is discussed. Certain limitations of the mass spectrometer as an analytical tool are also discussed.

Manufacture: Processes And Plant

Pressure Drop in the Flow of Compressible Fluids, W. E. Lobo, L. Friend and G. T. Skaperdas, *Ind. & Eng. Chem.* **34** (1942) pp. 821-23.

Pressure drop in the flow of compressible fluids is affected by changes in kinetic energy and fluid density to a degree dependent on the flow in question. An integrated formula must include the effect of kinetic energy changes to be fundamentally sound. Such a formula, that can be solved readily by means of a simple chart, is presented. Use of the formula and chart is illustrated, and the results obtained are compared with those secured by the use of other methods. In the example given it was found that the pressure drop calculated without considering kinetic energy changes was 25 percent less than the correct value calculated to include kinetic energy changes. Evaluation of a dimensionless group, found in the course of the derivation, can be used to determine the need for considering kinetic energy changes.

Heat Transfer and Pressure Drop for a Fluid Flowing in the Viscuous Region through a Vertical Pipe, R. C. Martinelli, C. J. Southwell, G. Alves, H. L. Craig, E. B. Weinberg, N. F. Lansing and L. M. K. Boelter, *Trans. Amer. Inst. Chem. Engrs.* **38** (1942) pp. 493-530.

In order to establish more precisely the effect of free convection on heat transfer in the viscous region, the authors obtained data on a system of vertical heat exchangers varying in dimensions and with uniform tube wall temperature. The data secured are presented in considerable detail. The conclusion was reached that the Colburn empirical function is not generally available to heat transfer in the viscous region in vertical pipes. An equation is presented that reasonably represents the experimental data obtained. The gradient of change in pressure in known isothermal fluid flow in the viscous region is not constant, but varies with distance along the pipe. An equation is given that predicts pressure drop within fair agreement of the experimental data.

A Simplified Heat Transfer Correlation for Semi-Turbulent Flow of Liquids in Pipes, R. H. Norris and M. W. Sims, *Trans. Am. Inst. Chem. Engrs.* **38** (1942) pp. 469-92.

The authors present equations and curves for heat transfer coefficients, for liquid flow which is neither fully streamline nor fully turbulent, but of the intermediate character that occurs when the Reynolds number lies between 3500 and

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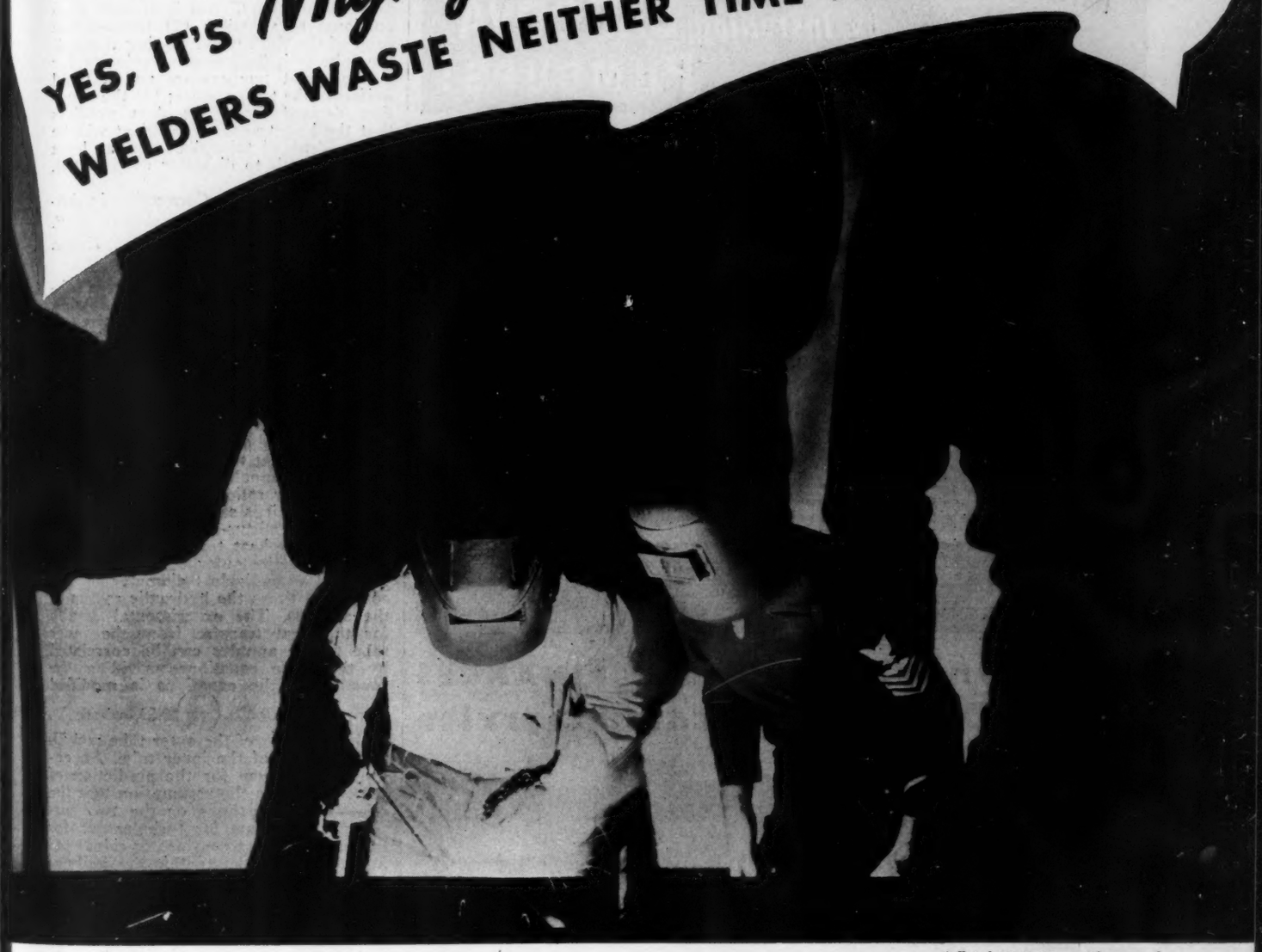

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11,000. The correlation given is believed to be simpler and more accurate than those previously available, but has been derived only for liquids having a Prandtl number between 35 and 140. Within the range of study of the variables the authors conclude: (1) surface heat transfer coefficient is directly proportional to velocity; (2) temperature drop of the fluid while passing through the tube is independent of velocity for a fixed inlet temperature and a fixed uniform tube temperature; (3) the equation derived from the data predicts that the heat transfer coefficient will be independent of tube diameter, at least for the length to diameter ratio tested.

Heat Transfer by Convection in Annular Spaces, C. C. MONRAD AND J. F. PELTON, *Trans. Amer. Inst. Chem. Engrs.* **38** (1942) pp. 593-611.

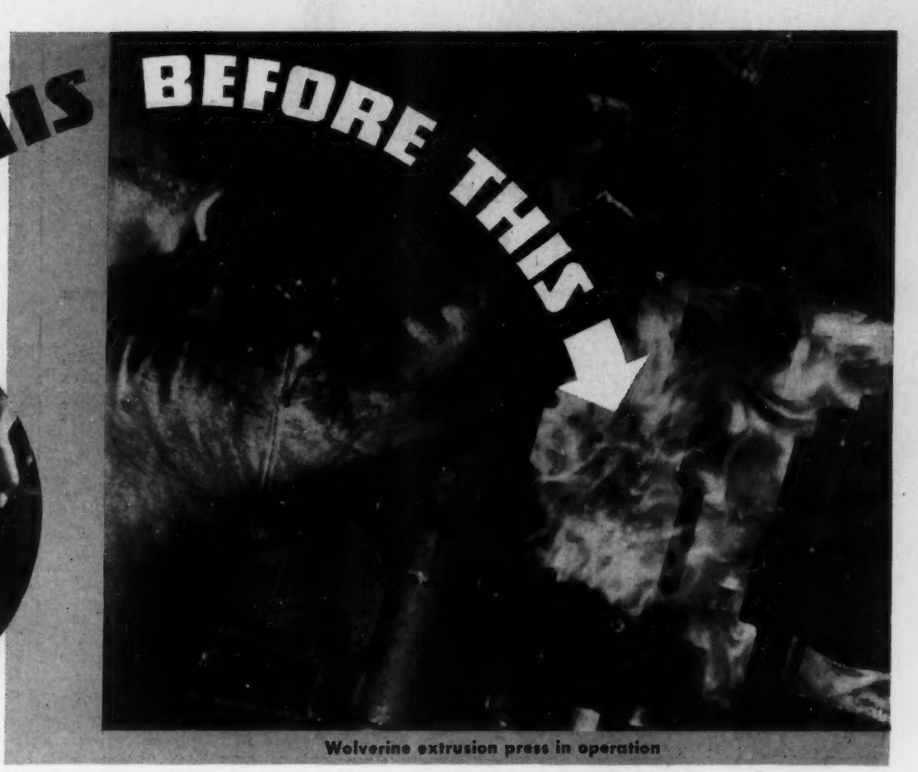
Heat transfer coefficients were obtained experimentally for fluids flowing in turbulent flow in concentric circular annuli. The investigation covered heat transfer for the inner tube of the annulus at three ratios of outer to inner tube diameters, namely 1.65, 2.45 and 17, using water and air over a temperature range of 80° F. to 180° F., and with Reynolds' numbers varying from 12,000 to 220,000. Heat transfer from the outer tube to the annular space was studied at a diameter ratio of 1.85. The results indicate that it is satisfactory to use the well-known Dittus-Boelter or Colburn equations for heat transfer in tubes for the case of the outer annulus surface, provided an equivalent diameter is used equal to 4 times the hydraulic radius of the annulus. The experimental results for the heat transfer from the inner tube to the annulus can be correlated by the same equations providing the constant in the equations is modified from 0.023 to $0.020 \left(\frac{D_1}{D_2}\right) 0.53$, where D_1 is the diameter of the outer tube and D_2 the diameter of the inner tube. An expression is given for the prediction of the constant on the assumption that the relative skin frictions on the two surfaces is the same for turbulent as for viscous flow. The constant so calculated agrees with the data within the limits of experimental error. It is recommended that this equation be used in preference to the more simple form.

Transfer Processes in Annuli, J. H. WIEGAND AND E. M. BAKER, *Trans. Amer. Inst. Chem. Engrs.* **38** (1942) pp. 569-92.

The rate of transfer of energy as friction and heat and the rate of transfer of material are closely related to the measurements of turbulence in flowing streams. Data on these processes were collected and correlated by the authors for small annuli on the basis of the "j factors" of Chilton and Colburn. The most suitable value of the Reynolds' number to measure turbulence in annuli is believed to be one whose equivalent diameter factor is the difference of the two annular diameters, or $d_2 - d_1$. With laminar flow, if the ratio of inner to outer diameter of an annulus is between 0.85 and 1.0, the annulus is best regarded as two parallel plates. If transfer takes place at both inner and outer walls of the annulus, the value of "j" can be computed without serious error as

$$\frac{12\mu}{(d_2 - d_1)\ up}$$

both for the above case and for all other



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FIRE and how to fight it!

HOW DO YOU KILL

FLAMMABLE LIQUID BLAZES?

Q. What are flammable liquid fires?

A. They are fires in oils, gasoline, solvents, paints, lacquers, and the like. Authorities call these Class "B" blazes and recommend extinguishers with a *smothering* or *blanketing* action.

Q. Will every type of extinguisher work on all kinds of flammable liquid fires?

A. No! Water streams, for example, are usually ineffective and extinguishers which employ a liquid stream will not handle three-dimensional blazes.

Q. What is a three-dimensional fire?

A. It is a fire which burns at more than one level, as when a container ignites and spills a flowing stream of burning liquid over its sides. Carbon dioxide extinguishers readily handle this type of fire. Work from the bottom up. Kill the fire at the lowest level first.

Q. What is a running fire?

A. It is a flammable liquid blaze which occurs when a flowing stream becomes ignited. You fight this fire by working against the flow of the liquid. If a pipe is leaking, start at the extreme edge of the fire and work back toward the pipe. If a container is spilling its burning contents, work toward the container.

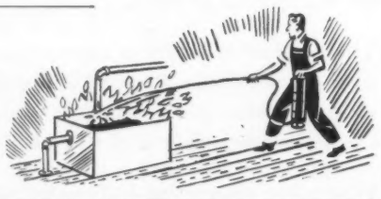
Q. What is a spill fire?

A. This is simply a fire resulting from liquid spilled on the ground or on the floor. Don't try to kill all of this fire at once, if it covers a large area. Start at one point, smother all flames there and continue, part by part, until the entire fire is out.

If you are outdoors, *keep wind at your back.*

Q. How about fires in open vessels?

A. Always "bank" stream from foam or vaporizing liquid extinguishers off inside wall of container. Don't squirt directly on burning surface. With carbon dioxide units, aim discharge at nearest portion then work up on fire with slow sweeping motion.



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annuli except those having values of the ratio of inner to outer diameter below 0.05. For cases of transfer from both walls in turbulent flow, the values of "j" do not vary with the diameter ratio and are equal to the values for a round pipe whose diameter is equal to the difference of the anular diameters. In turbulent flow if transfer occurs at one wall only, the values of "j" vary with the ratio of the inner to outer wall diameters, the values decreasing with the ratio when transfer occurs on the inner wall, and increasing when transfer occurs on the outer wall. Data at hand were insufficient to establish reliable equations for these cases.

Condenser-Subcooler Performance and Design, A. P. COLBURN, L. L. MILLAR AND J. W. WESTWATER, *Trans. Am. Inst. Chem. Engrs.* **38** (1942) pp. 447-68.

The paper presents an experimental study of the type of vertical condenser for organic vapors in which the vapors pass downward inside tubes and the tubes are of sufficient length so that the condensate is cooled to a temperature approaching that of the inlet cooling water. The test condenser used was a single ¾-inch I.D. copper tube, about 3 feet long, cooled by water flowing upward in a narrow annular space in spiral motion. Temperatures were measured at small intervals along the tube. Rates of vapor flow were varied from a value high enough so that some uncondensed vapor passed through the condenser, to lower values with various degrees of cooling. The condensing film coefficients of heat transfer were in satisfactory agreement with the Nusselt equation. The cooling film coefficients were in satisfactory agreement with the equation for heat transfer to vertical liquid layers in laminar flow developed by Drew, Bays, and McAdams. The design procedure recommended includes: estimation of the average condensate temperature at the end of the condensing section to permit a breakdown of the total heat load into that in the condensing section and that in the subcooling; prediction of the separate film coefficients in each section by methods mentioned above; selection of proper mean temperature differences in each section; and finally, calculation of the tube length for each duty, the sum of which gives the total length of the condenser tube required for any given number in parallel.

Petroleum Research and Wars, B. T. BROOKS, *Ind. & Eng. Chem.* **34** (1942) pp. 798-803.

The author reviews the status of the petroleum industry at the time of World War I and at the present time. In 1940, as compared with 1914, the American petroleum industry produced five times as much crude oil, thirteen times as much gasoline, had nineteen times the tonnage of tankers and twenty times the trained research personnel. The number of research workers in the petroleum industry is now about 6000, of which approximately half are highly trained scientific men. There are 563 research workers for every 10,000 wage earners in the refining branch of the business. This ratio is approximately double that obtaining in the chemical industry. The relation of the petroleum industry to the production of synthetic rubber is reviewed historically and currently. The development of 100-octane gasoline is

ARE NOT EXAGGERATED

When a bomb does its demolition duty for democracy, more than a little credit for its persuasive powers must be given to the petroleum industry. For the industry now supplies most of the Toluol in the bomb's TNT, and there's a greater supply at a lower price because of this development. But the "boom of the bomb" is not the last you'll hear from Toluol. When democracy's present job is accomplished, Toluol will then turn from destruction to construction — to help America enjoy its peace and security. Then it will become, among other things, a new source of comfort and beauty for American homes — a "leather" for easy chairs and other furniture. ¶ This is but another example demonstrating how the petroleum industry is contributing to Victory with new developments that will have even more value in peacetime. As it has for so many years, Ohio Seamless expects to supply seamless tubing for "oil's" expansion and development. Now, Ohio Seamless, too, is manufacturing the tools of war. VICTORY COMES FIRST! ¶ But out of this experience, Ohio Seamless is also developing new skills and techniques in seamless tube manufacture which will help speed the reconstruction achievements for the petroleum industry. Here, too, "reports are not exaggerated."

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considered, and progress traced from the early days of the industry to the present time. Toluene from petroleum is briefly discussed, and finally, the manufacture of synthetic chemicals from petroleum is considered. Chemical products made at present in substantial quantity are noted. Developments in the field of lubricants are briefly traced, and finally the author indulges in a few predictions with regard to the future of the industry.

Rapid Solution of Multicomponent Distillation Problems, G. KARNOFSKY, *Ind. & Eng. Chem.* **34** (1942) pp. 839-43.

The author briefly reviews the methods of calculation of the number of theoretical plates required in multicomponent distillation. The method described in the article is stated to make possible a more rapid solution by the stepwise procedure. The only assumption made is the usual one of constant reflux rations above and below the feed plate. The method is essentially a revision of the Hibschman method and a new solution requiring only one operating line that applies to all components. The method of procedure is described in some detail and applied to a typical problem.

A New Mineral: Synthetic Rubber—Its Needs and Prospects, M. B. HOPKINS, *Mining & Metallurgy* **23** (1942) p. 151.

Dr. Hopkins reviews the subject of synthetic rubber. Early in the century it was found that 2,3-dimethylbutadiene could be slowly polymerized to a rubber-like product. Further study showed that butadiene could be made from butyl alcohol, ethyl alcohol, and from petroleum. During World War I Germany made and used Buna rubber from 2,3-dimethyl butadiene. In 1927 German chemists developed methods for making butadiene and produced Buna rubber. This was followed by the making of Perbunan or Buna-N from the copolymer of butadiene and acrylonitrile and Buna-S from the copolymer of butadiene and styrene. Perbunan is resistant to oils, both mineral and animal, and of dilute acid, alkalis and salts. Buna-S is not as valuable in its resistance to solvents, but has better electrical properties than either natural rubber or Buna-N. Buna-S was used for making tires in Germany. Butyl rubber, developed by the Standard Oil Development Company is a product of the copolymerization of olefins with diolefins sufficient to leave only enough unsaturation to permit vulcanization. The product is stable to the action of oxygen and chemicals. Its suitability for the manufacture of tires is still questionable.

Influence of Sulfur Compounds on Octane Number and Lead Susceptibility of Gasolines, J. G. RYAN, *Ind. & Eng. Chem.* **34** (1942) pp. 824-32.

Previous work on the subject of the effect of sulfur compounds on the antiknock properties of gasoline and on the lead susceptibility is briefly reviewed. It is now well understood that the antiknock characteristics of gasolines are impaired by the presence of sulfur compounds to an extent dependent upon hydrocarbon structure and type of sulfur compound. The effect of the structure of sulfur compounds on the extent of the influence of sulfur compounds on

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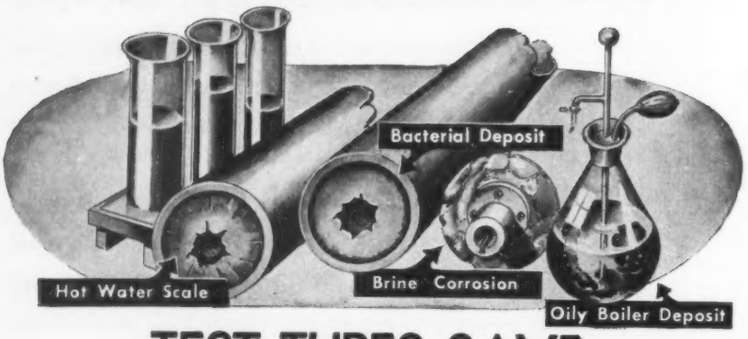

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susceptibility to tetraethyllead has been investigated quantitatively. A relation independent of hydrocarbon composition has been established between concentration of various types of sulfur compounds and lead susceptibility. This mathematical expression permits accurate evaluation from sulfur group analyses of the improvement obtainable by partial or complete desulfurization, the effect of gasoline sweetening methods, and the effect of blending stocks of similar hydrocarbon composition but different sulfur contents. The effect of sulfur compounds upon octane number in the absence of tetraethyllead varies with the size and structure of the hydrocarbon portion of the molecule as well as with the type of sulfur compound. The investigation reported by the author included three phases: first, the addition of purified sulfur compounds to the reformed gasoline of low sulfur content; second, evaluation of the quantitative effect upon octane number and lead susceptibility; and third, applications of the result to gasolines of different hydrocarbon composition. Data are presented in considerable detail in fifteen tables and nine graphs.

The Structure of Mixed Hydrogenation Catalysts, H. MORRIS, *Trans. Ill. State Acad. Sci.* **34** (1941) p. 122.

Since nickel is ferromagnetic, but not readily soluble in copper, and dilute solutions of nickel in copper are not ferromagnetic, magnetic measurements can be used to show whether a copper-nickel system is comprised of mixed crystals or of a solid solution of nickel in copper or of both a solution and mixed crystals. A procedure involving measurements of ferromagnetism and of catalytic activity was followed in order to determine the nature of the change that reduced the activity of the catalyst. Copper containing less than one part per million of iron was found to be inactive in the hydrogenation of benzene. If activated with 1 percent of nickel, the copper reduced 60 percent of the benzene in 30 seconds at 175° C. The active catalyst was strongly ferromagnetic, indicating that the nickel was not in solution in the copper but was present as mixed crystals of copper and nickel. The catalyst heated at 350° for 2 hours was found to be only one third as effective as before, and only one third as ferromagnetic. The conclusion was reached that the catalyst loses its activity because it forms a solid solution of nickel and copper.

Production of Acetylene by Thermal Cracking of Petroleum Hydrocarbons, R. L. HASCHE, *Chem. & Met. Engr.* **49** (1942) pp. 78-83.

Acetylene has long been recognized as one of the most important and versatile starting materials for organic syntheses, particularly for the preparation of aliphatic compounds. Cracking of hydrocarbons has long been recognized as a potential source of gas. The technical difficulties have heretofore precluded the commercial installation. The work done on the subject is briefly reviewed by the author. In 1934 a program for commercializing the process of thermal cracking to acetylene was started by the Tennessee Eastman Corporation.

Data are given on the cracking of propane and of natural gasoline at temperatures in the range from 800° C. to 1370° C. It was found advantageous to recirculate a gas mixture of acetylene and ethylene. Under these conditions an acetylene yield of 27½ percent was secured from butane. For practical reasons it was thought that a regenerative furnace would be more advantageous than a tube furnace. Carborundum is the only commercially available refractory that meets the drastic requirements of high heat conductivity combined with a satisfactory coefficient of thermal expansion and physical strength. The difficulties in the design of a regenerative furnace are discussed. From data secured in the work it was finally possible to build a regenerative furnace in which the cracking results obtained equaled in every respect those in laboratory and wemi-works tube cracking. The thermal process can be operated in a single pass manner so as to produce both acetylene and ethylene, or by recycling of the ethylene to produce acetylene only. An important advantage of the process is that no special metals are required for the construction of the plant; ordinary steel and cast iron are satisfactory, since no corrosive conditions are encountered in any part of the process.

Products: Properties and Utilization

A Simple Viscometer for Research and Control, F. C. Croxton, *Ind. & Eng. Chem., Anal. Ed.* **14** (1942) pp. 593-5.

The routine determination of the viscosity of petroleum products has been greatly improved in recent years as a result of the adoption of capillary-tube instruments in the A.S.T.M. standard methods. Several capillary-tube viscometers have been described in the literature. All possess certain individual advantages and disadvantages. It was believed by the author that practically all the advantages could be incorporated in one viscometer that would be equally usable in routine or research work. The instrument described in the article was designed to meet requirements as to accuracy, speed, cost, flexibility, and ruggedness. The instrument is relatively inexpensive, can be used rapidly, and is characterized by accuracy equal to any of the accepted kinematic viscometers. A variation suitable for use with opaque liquids is presented. The instrument is described in some detail, as well as the operating technique for its use.

Determination of Small Amounts of Benzene in the Presence of Cyclohexane, B. B. Corson and L. J. Brady, *Ind. & Eng. Chem., Anal. Ed.* **14** (1942) pp. 531-33.

The method described in the paper consists in measuring the temperature rise caused by the interaction of benzene or toluene with nitrating acid under definite conditions, and reading the percentage of aromatic from a curve relating T with hydrocarbon composition. The method is described in some detail, and the effect of strength of nitrating acid and of initial temperature are discussed.

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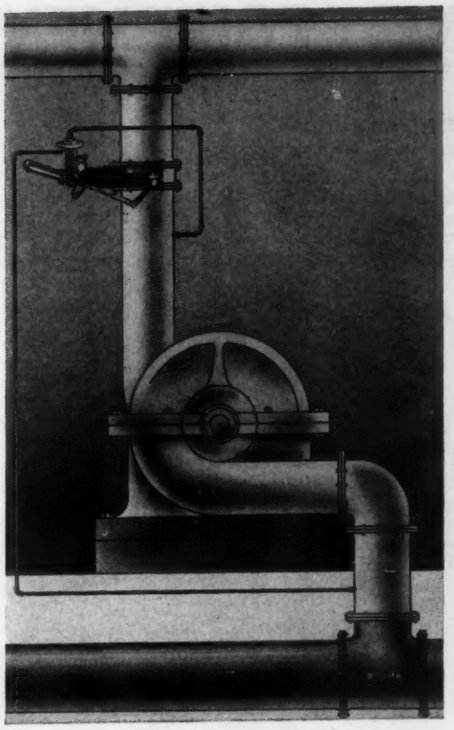

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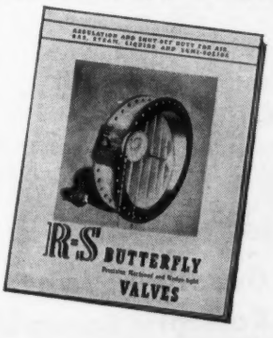

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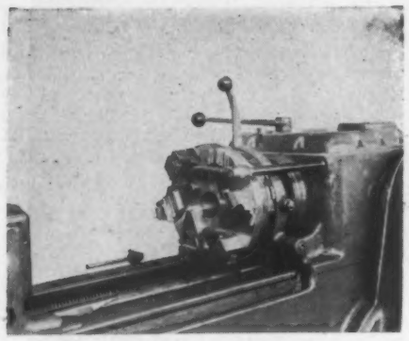


Landis Die Head

face of the die head to support extended chaser holders.

The die head illustrated is equipped with chaser holders and chasers for threading 9¾-inch diameter — 8 pitch. However, by employing chaser holders with a still greater offset seating surface for the chasers, diameters as large as 12 inches can be handled very efficiently. The maximum thread length which can be handled with chaser holders of the type illustrated is approximately 2 inches.

The special Lanco die head, identified as type RXX is being used very successfully for threading components manufactured by the munitions industries. All operating parts of the die head are made of high carbon steel and are heat treated. The chaser holders are made from steel forgings and since these holders are supported by the enlarged closing ring, they provide an unusually rigid support for the chasers.

It is especially suitable for threading large diameter, fine pitch threads where the thread length is relatively short.

Fiber Container

MACMILLAN PETROLEUM CORPORATION

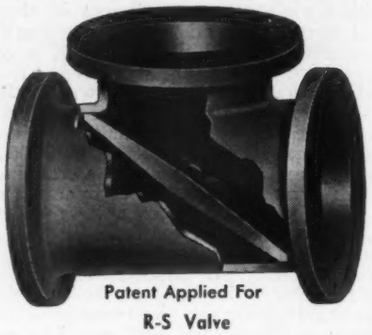
Macmillan Petroleum Corporation, 530 West Sixth Street, Los Angeles, is manufacturing a substitute for tin cans from fiber for shipping and handling lubricating oil. Raymond S. Macmillan, president of the company, has announced that the container will be made available to the refining industry. His opinion is that it may also have use for the food industry.

It is a three-ply spirally wound paper container, which is made durable by the application of three plastics, whose base is grain, flax seed, animal tissue, bones and similar ingredients.

Valves

R-S PRODUCTS CORPORATION

R-S Products Corporation, Philadelphia, has announced a three-way valve of the butterfly type which provides unusually quick action when placed in use. It is designed for mixing and quick interchange service and adapted to fully



Patent Applied For

R-S Valve

automatic control by means of an air diaphragm motor or hydraulic cylinder.

The valve is constructed of cast steel or cast iron for pressures up to 600 p.s.i. When desirable, special metals for resistance against heat, abrasion and corrosion can be substituted with a consequential saving in cost.

A special feature of the valve is the self-cleaning, double-beveled, streamlined vane. It seats wedge-tight against

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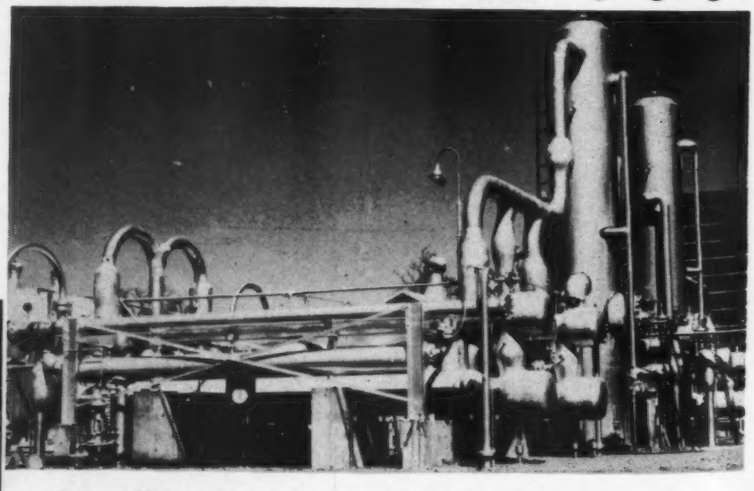
AND DOING IT WELL

. . . accounts for the repeat business we get from leading companies.



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T&R Construction Company, Inc.

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Information supplied by "Petroleum Refiner"

Proper instrumentation maintains correct operation and uniform product quality—protects equipment—avoids the cost of reprocessing spoiled products.

With instruments equipment corrosion often can be reduced or eliminated. A Kentucky refiner, troubled by excessive corrosion of a crude-to-gasoline vapor heat exchanger on a distillation unit, installed a pH indicator to show hydrochloric acid or excess ammonia in the condensed process steam from a gasoline reflux drum. Injection of ammonia to the crude could then be so closely controlled that 218 days passed without tube corrosion in the exchange, saving down-time and new tubes.

Most economical operation of a Pacific Coast catalytic polymerization unit was found to require that total feed gases contain 18-20% olefins. Metering the raw feed and recycle gases, maintaining most economical operation.

Today's demand for practically pure products for explosives, aviation gasoline and synthetic rubber calls for constant maintenance of such factors as: temperatures, pressures and rates within narrow limits. Proper instrumentation is the most effective means of accomplishing these results.

CLIMAX FURNISHES AUTHORITATIVE ENGINEERING DATA ON MOLYBDENUM APPLICATIONS.
MOLYBDIC OXIDE—BRIQUETTED OR CANNED • FERROMOLYBDENUM • "CALCIUM MOLYBDATE"

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MOLY

the body of the valve thus producing a tight shut-off as well as positive control of volume and pressure.

For inaccessible locations, a reach rod with de-clutching unit is provided for automatic operation or manual control in case of power failure.

Cross Type Valve

MERCO NORDSTROM VALVE COMPANY

Merco Nordstrom Valve Company has announced a special hypreseal valve with unequal flanges and two side outlets for cross connection, made of alloy steel with round opening for 3000 pounds (W.O.G.) working pressure, and capable of a 6000-pound test. The valve is worm gear operated.

The flange sizes are 3 x 8 x 3⅛ x 2 x 2; end flanges are 900 series and side outlet flanges are 1500 series.

Merco Nordstrom Valve

This type of casting was originated by Merco Nordstrom Valve Company to effect a more compact and more economical Christmas tree by the elimination of two flange joints. The large bottom flange bolts directly onto the tubing head, thus eliminating the unequal-flanged spool formerly used, doing away with one joint.

The integral cross does away with the standard four-way cross fitting and effects the elimination of one joint — that between a standard valve and the conventional cross. Similar valves are also cast with but one outlet. The latter are designated tee type valves to distinguish them from the cross type valve shown in the illustration. Any combination of flange series can be supplied.

Crater Filler

GENERAL ELECTRIC COMPANY

General Electric Company, Schenectady, New York, has announced a new crater filler for use with the G-E strikeasy arc welder. The crater filler—a foot accelerator for welders—is designed to provide the very close auxiliary control of heat required in welding thin material, and to permit tapering off of the welding current at the end of a bead in order to fill the crater which is otherwise left.

Unfilled craters have sometimes proved to be the source of cracks which are harmful to the strength of a weld. Properly filled craters provide full strength at the end of a weld bead.

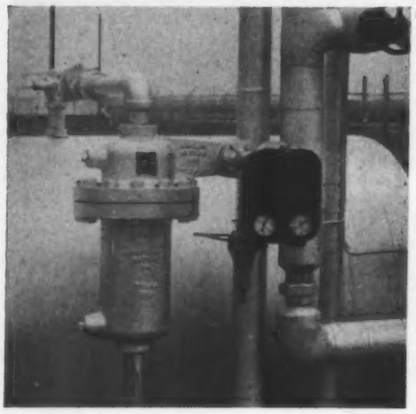
The crater filler is essentially a combination of a foot-operated rheostat for reducing the current and a field forcing switch for providing a hot start or an increase in welding current when required. It is not intended to replace the function of the control on the Strikeasy,

G-E Crater Filler

H-W DISPLACEMENT TYPE LEVEL CONTROLLER

AVAILABLE IN TWO TYPES

H-W Type 850 EXTERNAL TYPE



THE LEVEL CONTROLLER WITH NO STUFFING BOX ..... LEAKAGE ..... FRICTION

H-W Type 855 INTERNAL TYPE

Stainless Steel Torsion Tube anchored to the housing is supported by the bearing. Pressure in the cage is held OUTSIDE the tube. Inside of the tube at atmospheric pressure. Weight of the float actually twists the tube. Rising level reduces the effective weight of the float, causing tube to partially return to its normal position. The rod welded at the float connection transmits the rotation to the pilot mechanism.

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They resist CORROSIVE FUMES and withstand HIGH TEMPERATURES

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LONERGAN Pop Safety Valves, Pressure Relief Valves, and Pressure Gauges are made in a complete range of types and sizes. *Special constructions to meet high pressures, temperatures and other severe service conditions.* For information see your Supply House, or get in touch with our district representatives:

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Power Specialty Co., 25 N. Live Oak Street

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J. O. & C. U. Martin, 637 Minna Street

but is used to increase or decrease the heat setting to accommodate abnormal conditions at the beginning or end of a weld, or during a weld. Normal welding heats should be adjusted in the usual way.

The crater filler is particularly helpful when working with thin material where normal welding heats are low, as conditions frequently arise where normal welding heats are insufficient. At the start of a weld the electrode and base material are cold and fusion might be poor, with consequent pile-up of the deposited metal. A similar circumstance arises where the section to be welded suddenly becomes thicker, or when it is necessary to weld into or across a previously deposited bead.

In either of these circumstances, the crater filler gives adequate fusion when needed. The increased current is instantly available and the return to normal heat is instantaneous.

At the time of breaking the arc, the crater filler permits either a rapid or a slow decrease in current down to the point where the arc is extinguished. This assists the operator in mastering the technique of finishing a bead without a crater, because he can suit the rate of fading of the current to the conditions in that particular weld.

Protective Coating

UNITED STATES STONEWARE COMPANY

The United States Stoneware Company, Akron, is offering Tygon in formulations to provide for a non-adhesive coating for temporary protection to highly polished surfaces against rust, corrosion, grease, dust and scratches.

The product is prepared in liquid so it will form a stable film when dried, or as Tygon Temprotec, a clear or transparent colored formulation which may be applied by brush, spray or roller coating. It dries at room temperature and forms a durable elastic film which can be peeled off as a whole without injury to surfaces.

Circuit Breaker

GENERAL ELECTRIC COMPANY

General Electric Company, Schenectady, New York, has introduced a new high-speed air circuit breaker, which minimizes arc back. When presented at the summer convention of the American Institute of Electrical Engineers it was offered as a means of lessening the possibilities of power interruptions in continuous processes. It removes short circuits in less than one cycle.

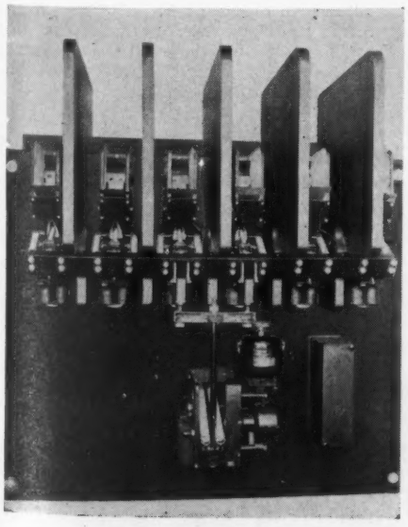
Part of the description made by J. W. Seaman and L. W. Morton was:

"In effect arc back is a short circuit on the power system during which the current can increase to excessively high values. They stated that in large installations where a number of rectifiers are operated in parallel, current increases greater than ten million amperes a second have been observed. For a single rectifier, the rate of increase of current can be as much as six million amperes per second.

"Such rates of rise are due to the fact that current flowing through the anode circuits of a rectifier immediately feeds into the anode circuit where the arc back occurs. Other rectifiers on the same bus will also feed into the faulty circuit. This reverse current flow in the circuit of the faulty anode circuit must be interrupted before it reaches proportions that will cause damage to the rectifier and associated equipment such as bus runs and transformers.

"By interrupting the circuit in less than one cycle, the new circuit breaker limits the current that can flow into the faulty anode to values of less than 50,000 amperes.

"One reason why the new breaker can do this is because its design utilizes the effect of magnetic loop expansion. This works to a double advantage. Where the circuit is normal, the increased pressure at the contacts prevents burning of their surfaces. But when the breaker is tripped during abnormal circuit con-



G-E Circuit Breaker

INTERLOCKED is One Rod Packing that
Can't Come Apart
J-M INTERLOCKED—the greatest single improvement ever made in braided packing
Once Interlocked is installed, you can be sure that repacking jobs will be few and far between. This unique braided material has no jackets to wear through or come apart . . . no plaits to loosen. It is braided square, and thus presents a better contacting area . . . provides a tight seal with minimum gland pressure.
For details, write for Catalog PK-12A. Johns-Manville, 22 E. 40th St., New York.
J-M Interlocked is available for prompt delivery . . . See your nearest J-M Distributor
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ditions, the magnetic loop expansion effect helps get the contacts separated quickly. Low-inertia moving parts in the device further speed the break.

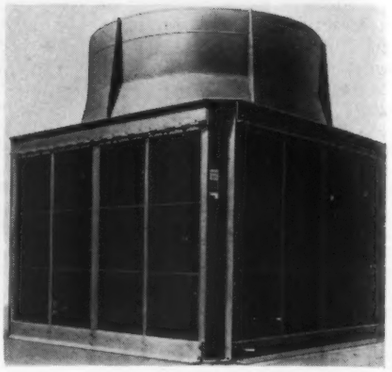
"A high-speed current directional trip initiates the opening of the contacts. Responsive only to the reverse current flow of an arc back, it starts the action of the new breaker in less than one half cycle. The breaker has an arc chute of the magnetic blow-out type which multiplies the magnetic effect of the current through it and rapidly lengthens the arc back to its extinguishing point. The breaker automatically closes the cleared circuit in about one minute."

Cooling Machine

YOUNG RADIATOR COMPANY

Young Radiator Company, Racine, Wisconsin, has designed a large cooling machine for internal-combustion-engine or compressor cooling and for cooling and condensing in processing plants. Several are being installed in by-products plants of aviation gasoline units.

It is an atmospheric unit with an induced draft fan, especially designed, mounted horizontally at the top of the tower and drawing air through the heat-transfer elements and discharging it upward through an aero dynamically designed discharge stack.



Young Cooling Machine

The unit is designated Quad because it is formed in a four-side assembly, each of which has heat transfer surfaces for water, oil or gas cooling and for steam or vapor condensing as required. Capacity is sufficient for handling both jacket water and lubricating oil of a diesel engine of 2000 horsepower. The component side members are individually assembled and supported so the unit can be erected at the point of operation by bolting each into position. It is 14 feet high and 12 feet square.

Variable Speed Drive

WORTHINGTON PUMP AND MACHINERY CORPORATION

Worthington Pump and Machinery Corporation, Harrison, New Jersey, has announced a new variable speed multiple V-belt drive. The drive is now offered in model A, which has a horsepower range from one third to three quarters, with a speed ratio of 16 to 1. Other sizes are now being developed. It can be directly connected to any standard motor and the output shaft can be run at motor speed and is flexible enough to be applied to any type of machine within its power range.

An interesting feature of this drive is its mechanical, positive belt-tensioning device which automatically compensates for increased arc of belt contact which results from changing from low to high speeds. In this tensioning device no springs are required. A further feature is the fact that the drive need not be dismantled to change belts.

Welding Electrode

LINCOLN ELECTRIC COMPANY

Lincoln Electric Company, Cleveland, has announced a new arc-welding electrode, Fleetwood 11, expressly for use with fillet technique arc welding. It is designed for maximum benefit in speed from the new technique. Although a fast flowing electrode it gives deeper penetration to the root of the joint.

High currents are used, the electrode is advanced at a higher speed and the weld metal penetrates into the corners where the two pieces of metal are joined. The electrode is held at an angle of 45 to 60 degrees with the horizontal plate and 90 degrees with the electrode path along the joint. The arc produced is so short, the electrode coating practically touches the metal.

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Cleaning faster than any other jet method, the Sellers Hi-Pressure Cleaning Jet tears heavy dirt and grease away with a force up to 270 pounds at 180° temperature. The hot water and the solvent soften the dirt; the high pressure tears it away. Sellers' units utilize steam at pressures from 50 to 125 pounds and unheated water at any pressure over 15 pounds. For more information about these time and money saving cleaning jets, write today for a catalog and prices.

For cleaning heat and exchanger bundles, cooling or heating coils, and hard-to-clean apparatus.

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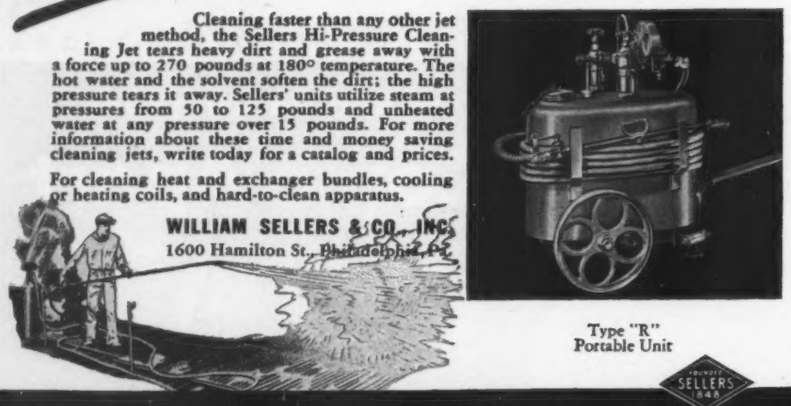
1600 Hamilton St., Philadelphia, Pa.



Type "R" Portable Unit

Sellers HI-PRESSURE CLEANING JET

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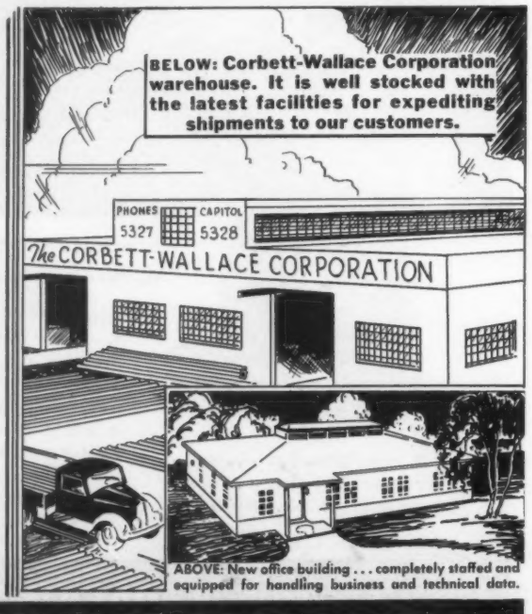
A complete line of Powell Vales for refinery, pipe line and production needs.

See Powell Valve advertisement on opposite page.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The CORBETT-WALLACE CORPORATION
ABOVE: New office building . . . completely staffed and equipped for handling business and technical data.

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Quality Products Plus Engineering Assistance

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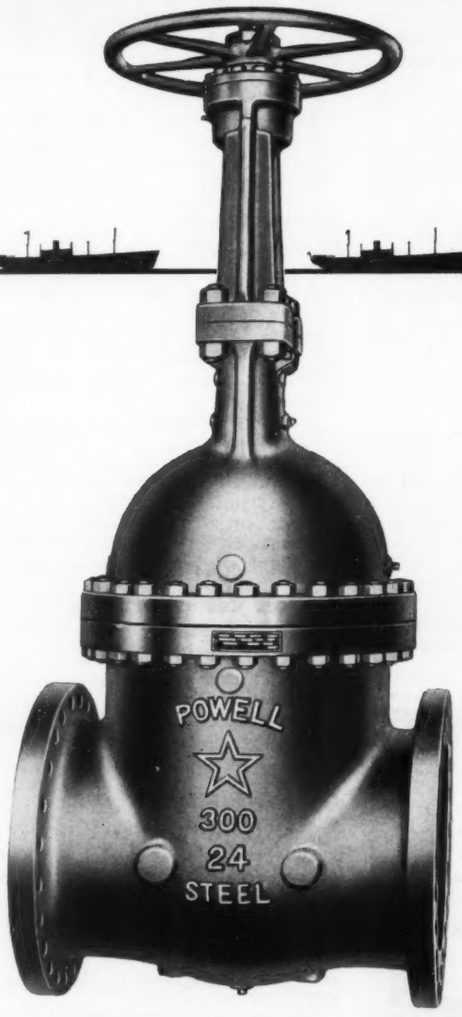

This 24″ Class 300 pound Cast Steel Gate Valve was designed and is built by Powell especially to meet the requirements of the Oil Industry. It has flanged ends, bolted flanged yoke bonnet, and ring type joints in body flanges. It is provided with stainless steel trim for a refinery gas reforming process. Available in sizes from 1″ to 30″.

THE need for ships in unheard-of numbers is urgent and pressing. The demand for oil will increase with each ship that is launched, each plane that takes off, each tank and each truck that is put into service. Oil is a constant necessity, and oil production must continue to increase as the war proceeds toward the Victory to which we have dedicated our lives and our fortunes.

For nearly a century Powell Valves have played an important part in the development of the Petroleum Industry. Special Powell Valves have been created to meet each new requirement brought about by this incredible development. Today the Powell Line meets the needs of the Industry in every respect.

Powell factories are running 24 hours a day to satisfy the demands of America's oil producers and refiners, ship builders, munitions makers, and other war industries. This they will continue to do until we have enough ships, enough planes, enough guns and enough oil to achieve that which alone will fulfill our pledge to civilization—Victory.

The Wm. Powell Company
Cincinnati, Ohio

POWELL VALVES

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If you need dependable Turbine repairs **in a hurry,** call us. We are completely equipped to repair and dynamically balance turbine rotors and any High Speed rotating elements in our modern shops.

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CHEMIST OR CHEMICAL ENGINEER

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☆ BUSINESS NOTES ☆

Betz Water Handbook Sells for 50 Cents

The Water Handbook of W. H. & L. D. Betz, Gillingham and Worth Streets, Frankfort, Philadelphia, was erroneously presented in the August issue of PETROLEUM REFINER as available without cost. The publication sells for 50 cents. It is a book of 65 pages, devoted to chemical analyses and interpretations of water conditions for industry.

In the first section, 25 different methods of water analyses are discussed at length, with procedures and calculations. Such water analyses as hardness, alkalinity, phosphate, sulfite, turbidity, oil, calcium and specific conductance are covered. With but one exception, all tests are simple, accurate determinations requiring little or no previous chemical background. Bacteriological analyses are not included.

The second section of the book is devoted to interpretations of the tests and their application to plant control. Included here are discussions of such subjects as carbonate and non-carbonate hardness, pH control, steam purity, inter-crystalline cracking, corrosion and many others.

Scattered throughout the handbook are 16 useful technical graphs and 15 illustrations of different pieces of testing equipment.

Change in Jas. P. Marsh Concern

The name of the E. A. Hill Company, Inc., a subsidiary of Jas. P. Marsh Corporation, Chicago, has been changed to Dependable Manufacturing Company, a division of the controlling company.

General offices of Dependable Manufacturing Company are at 2075 Southport Avenue, Chicago, with factory operations at 430 West Erie Street. The subsidiary is engaged exclusively in the production of tools in the manufacture of armaments.

Jarratt Now Manager of Martin's Houston Office

J. A. Jarratt, who has been manager of the New Orleans office of Charles Martin Company, has been transferred to the Houston territory, where the company maintains office and laboratory at 1215 Dumble Street.

J. A. JARRATT

Laboratory equipment recently has been enlarged to include crude oil classification and gas analysis in addition to inspection of oil. Facilities are provided for analytical work in the development of aviation gasoline and other critical war materials.

Jarratt is a graduate of Rice Institute, Houston.

Rowland Joins Carrier Staff

Harold L. Rowland has been appointed to the administrative staff of Carrier Corporation, Syracuse, New York, producer of air conditioning and refrigeration equipment. He has had extensive experience in business and financial fields.

He has resigned as president of George F. Getty, Inc., vice president and treasurer of Pacific Western Oil Corporation and vice president of Mission Corporation. His work with the Carrier organization also brought his resignation as managing director and president of Hotel Pierre, New York.

Hooker Company Gets Military Award

Hooker Electrochemical Company was awarded the Army and Navy E for its contributions to the production of essential military supplies. Presentation took place at ceremonies at the Niagara Falls plant September 8.

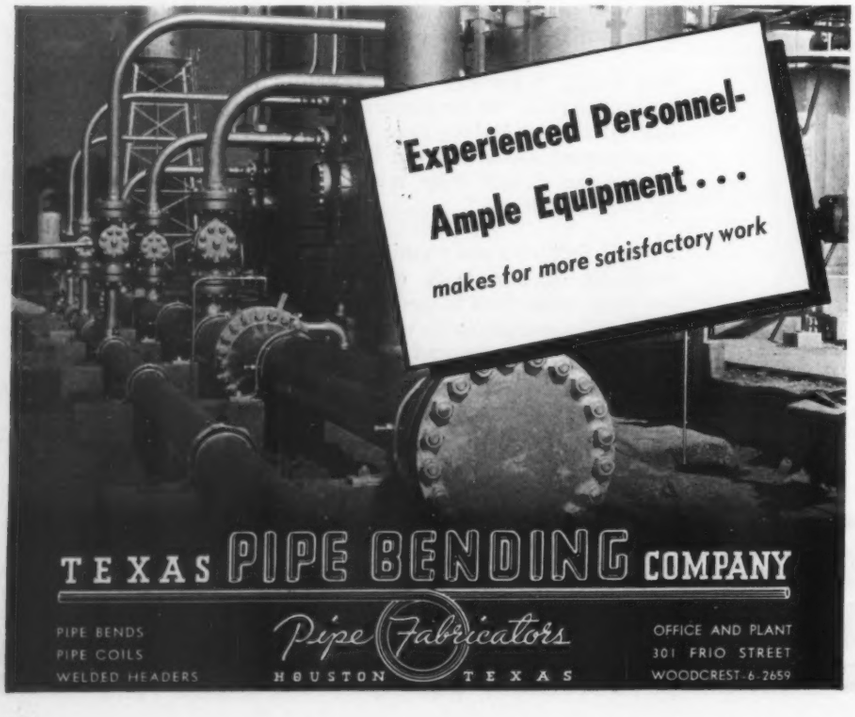
Cooper-Bessemer Gets Treasury Flag

Celebration of 100 percent subscription in War Bonds was combined with completion of the addition to foundry facilities at the Mount Vernon, Ohio, works of the Cooper-Bessemer Corporation. Employes of the company have pledged 11 percent of their payroll to purchase of securities.

The new foundry, which will house the core-making department of the plant at Mount Vernon, has a floor space 120 feet wide and 140 feet long. It contains seven core ovens, four of these built large enough to dry cores for huge castings, some of which go into compressors weighing as much as 110,000 pounds.

One of the unique features of the new core shop is the method of handling the large volume of sand used in core making. A spur track has been brought alongside of the building with hoppers arranged underneath so that sand may be dumped from cars and hoisted when needed from the hoppers into the sand muller.

The new building was elaborately



G. A. WELDING *Shop Notes*

PIONEER

The first welded pressure vessel to be approved by Hartford Steam Boiler Inspection Service was made here. This plant was a pioneer in applying electric welding to steel plate fabrication . . . in removing restrictions on wall thickness (walls up to 6" thick can now be successfully shaped) . . . and, above all, in perfecting the exclusive G. A. process, "Fluid-Fusion" Welding. It's your No. 1 source for steel plate equipment.

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PLATE & WELDING DIVISION
PLANT AT SHARON, PA.

Offices In All Principal Cities

decorated and lighted inside and out. The core ovens served as booths for refreshments and food, while the tops of the ovens were utilized as seating space. Large flags added to the decorations. Posters, stretching from one end of the building to the other, bore anti-Axis slogans.

Wheelco Sales Outlets In South America

Wheelco Instruments Company, Chicago, has named three additional sales outlets in South America: Argentina de Ingreneiria Industrial, 375 Peru, Buenos Aires; Miguel Khalife with A. P. Green Chilena Ltda., Casilla 13297, Santiago, Chile; and Benech & Cia, Cerrito 455, Montevideo, Uruguay.

Table of Common Hazardous Chemicals

The National Fire Protection Association has released its sixth edition of "A Table of Common Hazardous Chemicals." It was prepared in cooperation with the American Chemical Society.

The tabulation is sold for 25 cents through National Fire Protection Association, 60 Batterymarch Street, Boston.

The column on fire fighting phases gives the best extinguishing methods for fire in the chemicals listed. The latest information on shipping containers and storage safeguards, fire and life hazards is given for individual flammable chemicals.

This latest edition includes all the amendments adopted since 1931; it also includes additional chemicals and information on fire fighting phases and a new paragraph on oxygen-breathing equipment or helmets. Other paragraphs cover flammable limits and explosive range, ignition temperature, propagation of flame and flash point.

Manager of York Industrial Relations

Joseph E. Moody has been appointed manager of industrial relations of York Ice Machinery Corporation, York, Pennsylvania. This is a new department, which will embrace all phases of industrial and personnel relations.

Moody is a graduate of Cornell University who has had wide experience in personnel work. From 1930 until 1937 he was secretary of the Manufacturers Association of Hartford County, Connecticut. During 1937 he was personnel director of Hat Corporation of America and in 1938 became plant manager at the South Norwalk plant.

He is a member of the advisory committee on industrial relations and the speakers committee of the National Association of Manufacturers.

Callahan Promoted in Goodrich Organization

J. T. Callahan has been appointed western district manager of the B. F. Goodrich Company, national sales and service division, and will have headquarters in Chicago. He succeeds Walter W. Thomen, who has gone to military duty.

Callahan joined the Goodrich organization in Oklahoma City and served in sales capacities in Dallas and New Orleans before being transferred to Akron in 1938. Until his new appointment, he had been engaged in special

"Saluting"...

THE FLYING FORTRESS —BOEING'S FAMED B-17-E

Out-flying, out-fighting and out-bombing anything it meets in the air—on any front, the Flying Fortress has a reputation of proven superiority. It is a masterpiece of skillful engineering born of wide research and countless experiments. To such war equipment Americans pay thankful and admiring tribute.

But for men who build such planes, those who train to fly them—and for millions of people at home, there must be an abundance of water. To a water system the name Layne is as famed as that of Boeing to long range bombers. Layne has built thousands of water systems—the very biggest in the United States. Layne likewise builds pumps—the kind that outpump, out-last and out-perform any deep well water producing equipment in any territory—on any task.

Layne's reputation, like that of the Flying Fortress has been proven the hard way—on the field of action. Layne Wells and Pumps by the hundreds are producing millions and millions of gallons of water for manufacturers, cities, railroads and the army and navy. For late catalogs, bulletins and detail information, address

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Layne-Northern Company.....Mishawaka, Ind.
Layne-Louisiana Company.....Lake Charles, La.
Louisiana Well Company.....Monroe, La.
Layne-New York Company.....New York City
Layne-Northwest Company.....Milwaukee, Wis.
Layne-Ohio Company.....Columbus, Ohio
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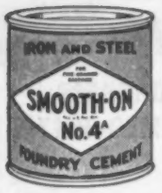
For repairing cracks in boilers, heaters, evaporators, condensers, pumps, and other castings; stopping leaks at pipe connections, bolts, rivets, seams, etc.; and tightening loose parts of apparatus and fixtures.

SMOOTH-ON No. 3
SMOOTH-ON No. 5

For making up tight screwed, flanged, hub or other types of pipe joints.

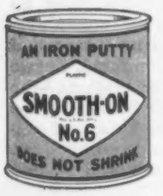


SMOOTH-ON No. 4

For truing up contours of castings and correcting surface blemishes. Selection of four grades to permit matching the color and grain of any iron or steel casting. Also foundry cements for brass, bronze and aluminum castings.

SMOOTH-ON No. 6

For making watertight joints at roof flashings, glass frames, foundation and window joints, filling in seams and rivet heads.



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For waterproofing walls and interiors of tanks and cisterns from the inside; for making hard, dustproof and oilproof concrete floors; and for repairing ruts, holes, and cracks in concrete floors.

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work in the company's production of war products.

Thomen, who was graduated from Ohio State University and Harvard Law School, joined B. F. Goodrich company in 1929 and was a member of the company legal and real estate departments before joining the national sales and service division three years ago.

Founder of De Laval Companies Dies

Francis J. Arend, founder and president of De Leval Steam Turbine Company, Trenton, New Jersey, died August 24. He was president of De Laval Separator Company. He was a director of Marine Midland Trust Company, Allenhurst Bank & Trust Company, Arex Indemnity Company and Fitkin Memorial Hospital.

President of Landis Machine Company Dies

John G. Benedict, president of Landis Machine Company, died August 4 after an illness of two years. He had been connected with the company since 1904, when he became secretary and treasurer. Previously he had worked temporarily in the office of the company. Although a native of Maryland, most of his life was spent in Waynesboro, Pennsylvania, headquarters of the company. After graduation from public school there and attending State Teachers College at Shippensburg, he taught school two years. Then he had brief connections with other business institutions before an executive position with Landis Machine Company.

He was president of Canadian Landis Machine Company, Welland, Ontario; president of the First National Bank and Trust Company, vice president of the Waynesboro Hospital and a former vice president of Frick Company, all of Waynesboro. He served two years as president of the National Metal Trades Association and had been a trustee of both Pennsylvania State College and Shippensburg Teachers Training College.

Seventh Edition of Welding Handbook

The seventh edition of "Procedure Handbook of Arc Welding Design and Procedure" has been announced by the Lincoln Electric Company, Cleveland. In this edition stress has been placed on information and help for men in shops, shipyards, airplane factories and ordnance plants. The edition has contributions from nearly 300 contributors. It has 1308 pages; 1810 illustrations; sells for $1.50 in the United States and $2.00 elsewhere.

The book explains more fully than ever before the various methods and techniques used in welding, with a view to speeding up welding design and engineering.

Illustrated more exhaustively and more clearly than ever before is the chapter on "Typical Applications of Arc Welding."

New and significant information is given in the new handbook on such subjects as welding symbols, new allowable stresses, pre-heating for welding, stress relieving, procedures, speeds and costs, "Fleet-Fillet" technique, general metallurgical characteristics of metals and alloys, weldability of aluminum alloys, tubular construction, appearance and styling of welded design and many others.

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